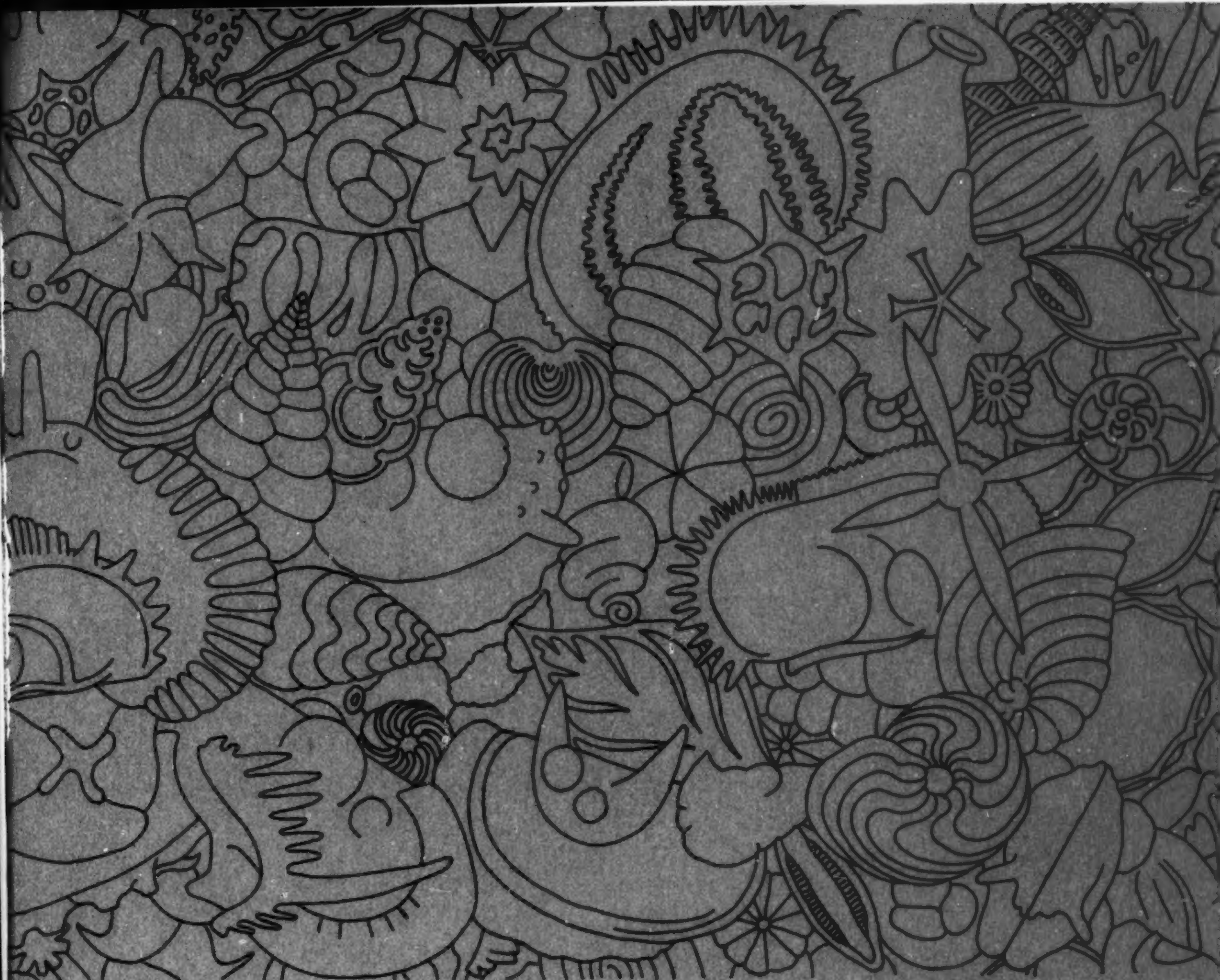

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foreword

articles

notes and comment

news reports

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foreword

The decision to publish "Micropaleontology" was reached only after long and careful deliberation. An investigation of the need for such a publication, as well as of its feasibility, was undertaken more than five years ago and continued until the middle of 1954. This investigation involved a poll of a cross-section of workers in this field, as well as private conversations with many others. The results of the poll, together with the outcome of other lines of inquiry, established without a doubt that such a publication is needed and desired by a great majority of those working in the field of micropaleontology. This investigation also plainly indicated that the new publication should cover the whole field of micropaleontology, and, moreover, that it should emphasize stratigraphic and applied micropaleontology rather than systematics.

The publication has been designed with these facts in mind. We have attempted to make it as functional as possible, and hope that our readers will find it pleasing as well.

The means of financing the publication for the first two or three years has been secured. Consequently, the subscription price has been set at a very low figure in order to insure as wide a distribution as possible. It is our hope that there will be sufficient subscribers to make it possible to keep the subscription price well within the reach of all.

However, all of these arrangements and facilities will not of themselves insure success in this venture. It can come only if all who are working in the field of micropaleontology will regard this new publication as their own. Only then can we hope to make it serve all of us in the best and most effective way. We need your suggestions, your criticisms and your papers, but above all else, your good wishes and moral backing. If we have these, we feel certain that the new quarterly will become a useful tool for workers in this field.

This publication is the culmination of the efforts of many people. We want to take this opportunity to express our thanks to all of those who have labored so long and earnestly to make it a reality. Their names are presented here:

Norval E. Baker	F. R. S. Henson	Cameron D. Ovey
R. C. van Bellen	N. de B. Hornibrook	S. R. N. Rao
Frederick A. Bush	Eugene Jablonski	H. H. Renz
Lawrence G. Christie	Robert E. King	Marcel Rey
D. Dale Condit	G. M. Knebel	Amos Salvador
Irene Crespin	Frederico W. Lange	Nestor J. Sander
Donald B. Eicher	Stuart A. Levinson	H. B. A. Swolfs
C. W. Flagler	Alfred R. Loeblich, Jr.	H. E. Thalmann
Hollis D. Hedberg	B. M. Miller	L. R. Wilson

For many years, the work of the Department of Micropaleontology has been generously supported by a number of major oil companies. This present venture is one of the direct results of their financial aid and moral backing. The following is a roster of these contributors:

Anglo-Iranian Oil Company	Socony-Vacuum Oil Company
Arabian American Oil Company	Standard Oil Company of California
Compagnie Française des Pétroles	Standard Oil Company (New Jersey)
Gulf Oil Corporation	Standard Vacuum Oil Company
Iraq Petroleum Company	Superior Oil Company
N. V. de Bataafsche Petroleum Mij.	The Texas Company
Sinclair Oil Corporation	Union Oil Company of California

We hope that all who have worked to make this quarterly possible will be pleased with "Micropaleontology."

THE EDITORS

ABSTRACT: *Taxonomy and ecology, biostratigraphy and ecology, and biostratigraphy and taxonomy of the foraminifera are closely related fields. It is shown, with reference to examples and to modern work on other groups of fossils, that an approach to any one of these fields which does not take into account their interrelations is not in agreement with modern standards.*

Taxonomic, stratigraphic and ecologic studies of foraminifera, and their interrelations

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INTRODUCTION

The study of foraminifera began as an investigation into their taxonomy, as it was then understood, that is, as an attempt to classify them according to their observed characters and to give them names by which they could be recognised and recorded by subsequent observers. At the same time their status as "index fossils" was investigated. The need for a third essential viewpoint, that of ecology, or palaeo-ecology, was soon recognised, but special studies in this field were undertaken only in recent years. While it is clear that studies in all three fields are required if micropalaeontology is to progress further, the fact that they are not independent but closely interrelated does not seem to be fully appreciated. An outline of the relations between taxonomy, biostratigraphy and palaeo-ecology of the foraminifera should help to avert over-specialisation which would leave vital boundary questions unsolved. That the problem is a live and topical one is shown by a number of publications related to its various aspects (Albritton et al., 1954; Boltovsky, 1954*a, b;* Emiliani, 1954; Papp and Küpper, 1954), which were received during preparation of this paper. Hiltermann (1951) has previously discussed some of its fundamental aspects from the viewpoint of foraminiferal populations in taxonomy, ecology and stratigraphy.

TAXONOMY AND ECOLOGY

Taxonomy is the science of classification of organisms, built upon the basic fields of morphology, physiology, ecology, and genetics (Mayr, Linsley and Usinger, 1953). At least since Darwin's day, taxonomy deals with the grouping of organisms in accordance with their known or inferred genetic relations, tending to reveal discontinuities of character combinations (Schilder, 1952).

While great progress has been made in the description of details of morphology, particularly relating to the tests of larger and smaller foraminifera, the study of their physiology and genetics has hardly started. Le Calvez, whose untimely death has interrupted most promising and valuable work along those lines, has shown that foraminifera, on account of their prolonged free-living haploid phase and incipient sexuality, should prove interesting objects for genetic studies. It is hoped that geneticists will, in due course, undertake experimental work on these organisms. The physiological basis for their taxonomy is almost wholly lacking, and where functional morphology is not yet possible owing to lack of observations and experimental data, descriptions tend to remain formal and stylised. This affects adversely the establishment of homology of parts of the tests and therefore the understanding of genetic relations.

Some artificial groupings, such as d'Orbigny's Stichostegia, have been eliminated, but that was not done on the basis of functional morphological analysis (Rhumbler's attempted mechanical explanation of evolutionary trends in foraminifera being a patent failure), but as a result of the application of the "biogenetic law." According to this "law" the various initial stages of uniserial tests were explained as inherited ancestral characters and were given a higher taxonomic value than the adult characters. The indiscriminate application of this principle is to be deprecated; it covers only one of a number of possible relations between ontogeny and phylogeny, as Sewertzoff, de Beer and others have pointed out. Some palaeontologists have suspected that the constitution of the wall of the foraminiferal test is an adaptive rather than a genetically significant character, but that is not generally correct

and there is no reason to doubt that the arenaceous, porcellanous, and hyaline foraminifera represent genetically significant and stable groups.

The need for functional evaluation of characters arises not so much in the higher levels of taxonomy as in relation to details such as the apertures, pores, and canal systems, which are used in the discrimination of families and genera. We must admit that we are completely in the dark concerning the functions and therefore the adaptive significance of different expressions of these characters. We know that the aperture functions in relation to growth (emission of protoplasm forming a new chamber), locomotion and feeding (emission of protoplasm forming pseudopodia), and reproduction, but the relation of specific shapes of this "organ" to variations of its function is unknown, and speculative statements that have been made are unsupported by observation or experiment. Such observations should be attempted. They are likely to revolutionise taxonomy. For example, the various *"Cribro-"* genera, which are distinguished solely on the basis of a cribrate aperture, mostly without even any reference to the ontogeny of this character, are suspect and may well include individual modifications or stages in the life cycle. In the Rotaliidea the occurrences of supplementary or divided ventral apertures (proto- and deuteroforamina), and of accessory or marginal apertures from which no chambers are formed, require functional analysis and until they are better understood too much taxonomic reliance should not be placed on these characters. Trends towards the obstruction of apertures are observed in various phyletic lines, but the ecological or physiological significance of such changes is unknown. The relation between reproduction, change of habitat, and morphology of the test is known in *Tretomphalus* and suspected in other genera, but such connections may be much more widespread. The suggested evolution, from tooth plates, of canal systems that are excretory, as suggested by Hofker, would represent a change of function.

It is generally believed that the distribution of foraminifera is mainly determined by temperature, but the physiological basis of this all-important ecological effect is entirely unknown. We know of the existence of eury- and stenothermal species, genera and (at least statistically) families. Similar relations can be observed concerning salinity, which are expressed in terms of euryhaline, stenohaline or brackish-water species and genera, though individual modifications in response to salinity changes have also been recorded. Abundance or exclusive occurrence of Astrorhizidea and Lituolidea in certain Recent and fossil communities is likely to be related to abnormal acidity, but the relations between this and carbon dioxide, oxygen, temperature, and possibly also other factors and their geochemical effects (e.g., deposition of montmorillonite clays, in which these faunas are often found) remain to be worked out. An excellent example of ecological analysis in terms of taxonomic units was given by Lowman (1949).

In all ecological studies taxonomy is basic, in the sense that expression of findings depends on accuracy of identification of taxonomic units. The validity of these units should not be taken for granted by the ecologist but should be approached critically. Firstly, some of Cushman's families are more heterogeneous in their basic morphology than their author had suspected, e.g., the Cassidulinidae, "Heterohelicidae" or Rotaliidae, and a generalized statement of their ecologic distribution is therefore rather meaningless. Secondly, the validity of taxonomic assumptions, such as the stability of certain character combinations, should be checked against ecological observations. It may then be found that in apparently wide-ranging forms certain additional characters of taxonomic value occur which enable distinctions to be made, or that the known characters are combined or expressed differently according to habitat. Thirdly, the basic assumption of a significant and stable correlation between ecology and supraspecific taxonomy should be checked. Some observations favour such correlations and thus support general statements. All planktonic foraminifera seem to have comon ancestors in early Cretaceous time; all Alveolinidae seem to have lived under similar conditions; all Nummulitidae favour warm and shallow water; certain deep-water assemblages of smaller foraminifera of Miocene age correspond closely to those from the same depth-zone in the present sea, though specific identity cannot be claimed. On the other hand, miliolid assemblages of different ages and different composition do not necessarily indicate similar habitat; the Jurassic lagenid assemblages cannot be ecologically placed by comparison with living lagenids.

There can be no doubt that more information on the ecologic distribution of Recent foraminifera is required, but the greatest need is not for lists of genera and species, or frequencies of "families" at different depths, but for a critical taxonomic analysis together with a determination of as many environmental factors as possible (depth, temperature, salinity, pH, oxygen, nutrients, sedimentation, etc.). This should lead to the analysis of the fauna of a basin of sedimentation or of a faunal province in terms of reactions to gradients of ecologic factors, regardless of whether the units recognised are taxa or assemblages of taxonomically unrelated populations.

Although we use the present as a key to the past, we should not forget that hidden in the past record are further keys which may be quite different from those supplied by the present fauna. Some fossil assemblages can be better understood on the basis of comparative palaeo-ecological studies than by far-fetched analogies with very different and often imperfectly known living assemblages. For example, the detailed study of foraminiferal populations in an exposed fossil reef-complex may be more rewarding than the equally detailed study of a living reef, because it would reveal changes in time and space, a dynamic instead of a static picture. Assemblages of arenaceous foraminifera may be better understood on the basis of their stratigraphic relation to normal assemblages.

Several important consequences arise from the fact that the basis of modern taxonomy is not the study of individuals but of populations, which possess an inherent amount of variability. Characters to be used in taxonomic discrimination are not those of individuals but of populations. This was recognised as early as 1865 by Schwager who, in his work on the foraminifera of Kar Nicobar, supplemented his diagnoses of species by discussions of what he perceived as the range of variability of each species. Unfortunately, his lead was not followed by later taxonomists. They were more concerned with the very necessary undoing of Brady's and other authors' excessive "lumping" and did not hesitate to describe single specimens as representatives of taxonomic units without testing whether these "units" were real or imaginary. They also ignored the fact that an objective statement of morphology alone, particularly of external morphology of the test to which they often confined their observations, is not sufficient to reveal taxonomic characters in the modern sense.

The dynamic equilibrium between the variable population and the variable environment cannot be understood on the basis of the study of a single specimen. The statistical concept of populations must become the unit, but it is the principle that matters, not the absolute number of specimens studied nor the refinement of statistical methods. As we cannot conduct breeding experiments with fossils, only the analysis of populations can show what characters are to be considered as heritable and what other characters are nonheritable individual modifications. The concave and occasionally cylindrical spiral surface of a *Cibicides* formed in connection with attachment to plant stems, or the multiple embryonic apparatus of *Simplorbites* or *Multilepidina*, are objective morphological characters of individuals but whether they are of taxonomic value or whether they occur as individual variants (modifications) depends on the analysis of populations in which they are found.

The principle of geographic speciation need not be discussed here. It is well known but has not yet been widely applied to marine invertebrates. Though Thalmann drew attention to the problem as it affects fossil foraminifera as early as 1934, his suggestions were not followed, probably because he used the wrong examples. As anyone who has studied faunal assemblages of equivalent age from different seas knows, polytypic species and superspecies (Mayr, Linsley and Usinger, 1953, pp. 28-29) are likely to exist in foraminifera and will be recognised sooner or later. In any one assemblage the establishment of a purely morphological infraspecific taxonomic unit would not be in agreement with modern biological thought and practice (Boltovskoy, 1954*a*). These units must also be separated in space or in time. The commonly used "*var.*" is a provisional unit, unanalyzed in its relations, and will be found to be either an extreme variant or individual modification, or else a geographic subspecies or a "transient" in time. The time aspect will be discussed in connection with stratigraphy. The establishment of geographic subspecies in foraminifera, living or fossil, will require careful, preferably statistical, analysis of very widespread collections. It seems likely that suitable objects for such studies will be found among certain pelagic foraminifera, as suggested by Thalmann, and also among some of the larger foraminifera, because of the larger number of observable characters.

BIOSTRATIGRAPHY AND ECOLOGY

The problem here is simply that of facies and their distribution in time. We are here concerned with biofacies, that is, with the contemporaneous occurrence of different fossil assemblages because of differences in ecological conditions, and of similar assemblages at different times because of similarity of ecological conditions. Lateral facies-changes are the rule rather than the exception, as no marine basin could have been inhabited throughout its extent by a uniform fauna. A high degree of uniformity is found only in deposits formed by widespread, shallow epicontinental transgressions such as those of the late Cretaceous, which are surprisingly uniform on all continents, even in species.

The analysis of foraminiferal facies is a prerequisite for stratigraphic correlation. It indicates whether observed differences between faunal assemblages are due to age or to ecological conditions. Facies (ecological) conditions determine the occurrence and abundance of certain elements in the fauna, but an exact knowledge of

these conditions is not required if we are concerned with the question whether different faunas can be correlated stratigraphically, i.e., when comparison rather than interpretation is the objective. Examples among well-known molluscan facies-faunas are the Kössen, Svabian, and Carpathian biofacies of the Alpine Upper Triassic (Rhaetian), or the pyritic ammonite faunas of the Jurassic and Cretaceous. The composition of these assemblages during a certain interval of geologic time is well defined and definitely known to be due to ecological factors, but their nature is not understood. Examples among the foraminifera are the different late Tertiary facies that LeRoy (1941) has found alternating in Sumatra, which also occur in New Guinea, and the various facies distinguished in the Mesozoic and Tertiary strata of Germany. The results of the analysis will eventually be expressed in a classification of facies or at least of elements which make up the various facies at various times, but at present this work is still in its initial stages.

Another problem is the evolution of biofacies in the course of geologic time. The elements of a fauna occupying a particular biotope not only evolve there but may be supplemented or replaced by others which originated or evolved under different conditions. Biofacies as such have a definite time-range. Foraminifera did not become planktonic before the Lower Cretaceous. The biogeochemical implications of this fact have been discussed by Kuenen (1950, p. 393). The characteristic assemblage of the chalk facies evolved during late Cretaceous and early Tertiary time and then became extinct. Brackish-water foraminiferal assemblages are not definitely known before the Oligocene. The biotope in the reef complex occupied by the fusulinids in late Palaeozoic time seems to have remained vacant, as far as foraminifera are concerned, during Mesozoic time, until it was reoccupied by nummulites and orbitoids. The evolution of biofacies, in this sense, is an important factor in stratigraphy and deserves careful study.

Time planes in foraminiferal stratigraphy, or horizons of correlatable faunal changes, are often, and most reliably, based on evolutionary changes in phyletic lineages, as, for example, in the cases of the fusulinids, of *Cycloclypeus* and *Miogypsina*, and probably also of *Globotruncana, Globorotalia, Hantkenina, Bolivinoides* and *Nummulites*, though many details of their phylogenetic relations are not yet fully understood. Many other time-markers, however, are based on the highest occurrences of species or genera, i.e., horizons of extinction. The theoretical basis for this procedure, which results from the preoccupation of practical stratigraphic micropalaeontology with bore material, is not clear. Faunal changes through simultaneous extinction of numbers of species must be due to some extent to facies changes, some of which could be nonrecurrent, at least for single basins of sedimentation, and therefore provide valid markers (Lowman, 1949, p. 1977). Any facies change may have stratigraphic significance, for example, a change from marine to brackish-water facies, provided the area within which the change occurred can be delimited and the geological event which caused it is known to have occurred rapidly enough throughout the area to make any possible time-lag between different parts of it negligible.

BIOSTRATIGRAPHY AND TAXONOMY

In most of Cushman's valuable monographs of foraminiferal families, the species are dealt with in stratigraphic order. This presupposes both reliability of age determinations and objective independence of taxonomic data from biostratigraphic successions. Unfortunately, both assumptions are often unwarranted. Even if the original age-determinations were correct, it would not be very helpful to describe, and to distinguish by differential diagnoses, all recorded Eocene representatives of, for. example, *Elphidium*, then all Oligocene species, and so on to Recent. As we are dealing with evolving populations, we can only develop a scientific taxonomy if we follow representatives of a species, a genus, or a family, through stratigraphic sequences in certain areas. This has become common practice in the study of corals, ammonites, belemnites (particularly of the Upper Cretaceous), lamellibranchs (Carboniferous, Permian and Jurassic), many other invertebrates, amphibians, reptiles (of the Karroo system) and mammals (horses and elephants). In the study of foraminifera, this approach is still exceptional, being confined to larger foraminifera and such Cretaceous forms as *Globotruncana, Bolivinoides*, and *Neoflabellina*. We have to face the fact that in the early stages of the approach to the problem of evolving populations, the *nomenclature* tends to become confused rather than clarified, but our primary concern is with taxonomy, the results of which are then expressed in the agreed terms of zoological nomenclature. Any attempt to put nomenclature first can only lead to a spurious taxonomy in which *scientific names* and their bearers, the *type specimens*, are classified instead of the natural phenomena which we wish to arrange in a system.

The stratigraphic position of a taxon is not a valid element of its *definition*. This must be purely morphological; in other words, two foraminiferal populations

which cannot be distinguished morphologically, but which are of different ages, must be considered identical. The stratigraphic position, however, enables us to *evaluate* morphological characters, and in this sense it must be taken into consideration. The differences between *Bolivinita* and *Bolivinitella*, and between *Lepidorbitoides* and *Nephrolepidina*, illustrate this point.

The main problems are, on the infraspecific and specific levels, the distinction between nontaxonomic individual variants and modifications, geographic subspecies, and transients in time or chrono-subspecies; on the generic and higher levels, the proper grouping on the basis of significant *character combinations* and the balance between vertical and horizontal classification (Simpson, 1944).

The rise of micropalaeontology was connected with the discrimination of minor morphological differences which made it possible to distinguish strata of different ages on the basis of foraminifera alone. Now that there can be no more doubt about the changes of foraminiferal faunas in time, there is no need to continue blindly in the same direction of minute "splitting" between any two individuals which may be of different ages and therefore, as names in faunal lists, helpful in biostratigraphic zoning. Enough material has been accumulated to turn to the analysis of populations, which is the only legitimate scientific practice in taxonomy. When that is done, we can follow the example of Tan Sin Hok's morphogenetic studies, or test the "plexus" concept (George, 1954, and references), or the proposals of Sylvester-Bradley (1951) and others, relating to the use of subspecies. In no other branch of palaeontology is it so easy to obtain large numbers of individuals (or samples of successive populations) from unbroken sequences of strata. The lag in the application of modern concepts to foraminiferal biostratigraphy can only be explained by historical reasons, but it cannot be justified.

Stratigraphic studies are not helped but are impeded by excessive proliferation of genera. Particularly objectionable procedures from the biostratigrapher's viewpoint are those which give precedence to formal nomenclature over taxonomy based on genetic and therefore time-related concepts. The selection of unsuitable but formally available type species which confuse generic concepts instead of clarifying and stabilizing them, and the replacing of well-established old generic names such as *Anomalina* and *Epistomina* because the type species may or may not possess characters usually present in other species assigned to those genera, are cases in point. Every newly described species adds something to the generic concept, and a very careful appraisal of all species currently assigned to the genus (including the type species and its holotype if the description is imperfect) is essential before that newly discovered character can be validly claimed to be of generic value. Unless a different origin can be established for aberrant species, it is preferable to designate them as a species-group or a subgenus.

This partial "revision" of existing genera from the point of view of the distribution of a single character results frequently in the separation of groups of species which are given formally valid new generic names. This could be and often is done, however, on the basis of another character, with entirely different results which lead to overlapping and irreconcilable classifications.

Genera are particularly important in stratigraphy, firstly, because they have wider geographic ranges than species and are therefore valuable for long-range correlations, and secondly, because their names are part of the binomina of the species. The practical stratigrapher has to know his genera, though he may temporarily record his species by numbers or letter designations. Any change in generic concepts and nomenclature is therefore a step to be undertaken with a sense of responsibility, not for formal reasons, but with the purpose of clarifying the evolution, and the distribution in time and space, of groups of species which can be reasonably claimed, on the basis of morphological and stratigraphic evidence, to be related.

Genetic relations are seen in palaeontology as morphogenetic relations in time. In this sense, taxonomy and stratigraphy are interdependent.

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ABSTRACT: *The stratigraphic occurrences of Paleozoic small-spore form genera in North America and Eurasia are discussed and compared. The system of classification proposed by Potonié and Kremp is used, although it is not acceptable in its entirety. The authors agree that a morphographic system, separate from botanical considerations, must be used for the practical application of these fossils to stratigraphic problems. Geological range charts are presented for small-spore genera (including three unpublished forms) recognized in North American rocks. An appendix includes the portion of the system of classification used by Potonié and Kremp that pertains to small spores, the European and Asian ranges of these genera, and critical comments by the authors.*

Geologic range of Paleozoic plant spores in North America

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INTRODUCTION

Plant spores and pollen can be obtained in abundance from the acid-insoluble residues of shales, as well as coals, thus making them a practical tool for the correlation of sediments. They are one of the few means of correlation between marine and terrestrial beds of equivalent age, because currents carry them into the seas, where they are deposited along with the remains of marine organisms.

The purpose of this paper is to compile the meager information covering the time ranges of plant small-spore genera in this country and abroad during the Paleozoic era. The lack of data is due to the taxonomic disagreement among workers on this subject, and to the fact that published major investigations have been confined to coals.

After this paper was completed, a copy was received of the article by Potonié and Kremp (1954) in which Paleozoic plant spores are arranged in a purely morphographic system for purposes of practical stratigraphic work. We agree with the morphographic viewpoint on dispersed spores. A major contribution to the study of spores has been made, which should encourage more workers to use these fossils. Some of the form genera of Potonié and Kremp are based on characteristics that overlap from one genus to another and are therefore of questionable practicality. The validity of a few of their genera under the Rules of Nomenclature is also questionable. In a few cases, genotypes of genera proposed by American authors have been placed in synonomy with similar species that occur in Europe. This should not be done without direct comparison of the specimens. Potonié and Kremp have erected a number of genera for megaspore types as well as micro- and isospores. A brief summary of their system of micro- and isospore classification is presented as an appendix to this paper, with our comments. Ranges for North America of the genera proposed by Potonié and Kremp are presented in this paper, but use of their genera does not imply complete acceptance of their work. Their names are used in order to facilitate comparisons of ranges of American and Eurasian forms. In order to preserve the concepts of the work of Potonié and Kremp, the writers have made drawings of some of their spore illustrations.

The authors wish to thank Dr. L. R. Wilson for his constructive comments during the preparation of the charts for this paper. Further thanks go to Miss Betty Fingerhut for her work in preparing the drawings and to Miss Carolyn Lipe for general assistance.

PRE-DEVONIAN

Land-plant spores and vascular plant remains have been reported from the Cambrian rocks (Vindhyan system) of India by several workers. K. Jacob, C. Jacob, and R. N. Shrivastava have studied shales belonging to the Lower Vindhyans and record "a number of spores belonging to the primitive land-plants, with well-defined triradiate markings, and having affinities with the ?Lycopsidae, ?Psilopsidae, and ?Sphenopsidae" (S. R. N. Rao, 1954). The same authors (1953) report vascular elements (tracheids, forty-three types of spores, and cuticle) from the Salt Range *Neobolus* shale, from Middle and Upper Cambrian shales of

Kashmir, and from the Upper Cambrian of Spiti. They state that woody elements from the Cambrian blue clay of Esthonia (Reissinger, 1952) are similar to those found in the Cambrian beds of India. Reissinger, however, reported mostly poreless spherical bodies similar to moss spores. Apparently only a few of the spores reported from India possess trilete marks. Some may be small animal cysts, which are present in marine sediments of all ages. Naumova (1949), Kopeliovitch (1951), Reissinger (1939, 1952), and Darrah (1937) have described spores of "vascular" plants from the Cambrian of Europe. All reports of trilete spores from Cambrian rocks need further investigation.

In *Monograptus*-bearing Silurian beds of Australia, plants possessing cuticle, stomata, and lignified vascular tissue have been found by Lang and Cookson (1935). The sporangia of *Baragwanathia longifolia* contain slightly oval spores with a diameter of approximately 50μ. The trilete marking is not discernible from published illustrations. They are all of the same size, and one would suppose that the plant was homosporous (Walton, 1940). *Zosterophyllum*, a plant that bears sporangia with spores about 75μ in diameter, is known from the Silurian of Australia and the Lower Devonian of Scotland, Germany, and the United States.

DEVONIAN

Spores formed in tetrads have been reported, but not described, from several genera of Devonian plants, including *Rhynia* (Middle Devonian Rhynie chert, middle Old Red Sandstone of Scotland), *Hornea* (same beds), *Psilophyton* (Lower Devonian: Gaspé of Canada, Norway, Scotland, Middle Devonian of Europe), and *Protopteridium* (Middle Devonian of Bohemia and China). These and other Devonian plants are representatives of the Psilophytales, Hyeniales, Protolepidodendrales, Sphenophyllales, Coenopteridales, and Cordaitales (Pityeae).

Descriptions of Devonian small-spore species are few in the literature. Naumova (1937) illustrated some species from the U.S.S.R. Thomson (1940) found seventeen types in the Middle Devonian of Esthonia, and Lang (1925) described nine types from the middle Old Red Sandstone. Hoeg (1942) illustrated several forms from the Downtonian flora of Spitzbergen. One large form (pl. 1, figs. 4, 6), found by the authors in Upper Devonian shales of western Canada, apparently is present also in the middle Old Red Sandstone of Cromarty (Lang, 1925), the Devonian of Quebec (Arnold, 1936), and the Downtonian of Spitzbergen (Hoeg, 1942). The descriptions of Devonian spores in these and other papers are not detailed, and comparisons are therefore difficult. Illustrations in this paper of Upper Devonian specimens are the first published from the Western Hemisphere. A detailed investigation of this plant-spore assemblage from western Canada is in progress.

Upper Devonian spores are extremely varied. Complex structures are developed, including bladders, flanges, girdles, thickenings, and large appendages, for some of which no function is apparent. It seems extremely unlikely that there is any straight-line increase in complexity among spore types. Spore form genera found in western Canada include *Apiculati-sporites, Calamospora?, Cirratriradites, Cristatisporites, Cyclogranisporites, Endosporites?, Granulatisporites, Latosporites?, Lophotriletes, Lycospora, Microreticulatisporites, Plani-sporites, Punctati-sporites, Reticulatisporites,* "Grandispora" and other unpublished genera. "Grandispora" is composed of a trilete central body and a relatively thick-walled spinose bladder (pl. 2, fig. 16).

Devonian species of the suites Laevigati and Apiculati are both spherical and triangular, and the lips of the sutures commonly are heavy and raised. Forms assigned to *Lycospora* generally are larger and have a thicker spore coat than later Paleozoic species. Some forms are placed in *Calamospora* on the basis of their spherical shape, contact areas, thin spore coat, and taper-point folds. Their calamarian origin is not proven. Species with a central body and spinose bladder are temporarily assigned to "Grandispora" (a manuscript genus of the authors for certain Upper Mississippian species), although they differ in many respects. *Cirratriradites* is represented by species ranging from about 30μ to 100μ in diameter with various types of ornamentation. A spherical monolete spore with prominent lips and a diameter of 50μ to 80μ, assigned to *Latosporites* Potonié and Kremp by the authors, is present in Upper Devonian shales of western Canada, as well as a monolete megaspore. A typically bean-shaped *Laevigato-sporites* from the same beds may have been a contaminant from other preparations.

Tasmanites, an alete questionable spore, is present throughout the Devonian section. The several species will perhaps become good index markers when they are better understood. A dark brown sphere with a circular "trap-door" may also be a usable form. Plant megaspores are abundant in some Devonian shales and coals. Plant spores will be extremely useful in Devonian correlations, especially in the black shale and siltstone sequences which bear few other fossils except hystrichospherids, scolecodonts, conodonts, and Chitinozoa.

MISSISSIPPIAN

Very little has been published on Mississippian plant spores. W. Berry (1937) described some spores from the Pennington (Mississippian?) coal of Tennessee. Schemel (1950) reported on the spores from the Lower Carboniferous (Visean?) Daggett coal of Utah. Luber and Waltz (1938) published on plant spores from the Tournaisian and Visean coals of the U.S.S.R., and Raistrick (1938) and Knox (1948) illustrated some forms from the Lower Carboniferous Limestone coals of Scotland and Northumberland. The authors have in preparation for publication a detailed study of spores from the Hardinsburg formation (Chester series) of Illinois and Kentucky. This paper includes twenty genera of plant spores, two of which are proposed as new. New genera are "Grandispora," and "Auroraspora" (trilete, relatively thick-walled central body suggestive of *Lycospora*, and a very thin non-reticulate bladder enclosing the central body (pl. 2, fig. 14). *Knoxisporites* Potonié and Kremp is also present.

Berry illustrated *Denso-sporites, Granulati-sporites, Cirratriradites, Laevigato-sporites* and possibly *Punctati-sporites* from the Pennington coal. From the Daggett coal, Schemel reports *Punctati-sporites(?), Granulati-sporites, Denso-sporites, Tripartites, Rotaspora, Verrucoso-sporites(?), Endosporites, Calamospora, Lycospora,* and two unnamed spore types possibly related to *Knoxisporites*. Among the Mississippian forms illustrated by Luber and Waltz from the Tournasian and Visean coals of the U.S.S.R. are the genera *Apiculati-sporites, Cirratriradites, Denso-sporites, Endosporites, Granulati-sporites, Leiotriletes, Microreticulati-sporites, Punctati-sporites, Reinschospora, Reticulati-sporites, Schulzospora, Simozonotriletes, Tripartites, Triquitrites,* "Auroraspora," and others. All of these forms have been found in Mississippian rocks of the U.S.A., except *Reinschospora*. From Knox's figures (1938), the spore genera found in the Limestone coal group of Scotland include *Cirratriradites, Granulati-sporites, Triquitrites, Tripartites, Reticulati-sporites,* "Auroraspora," *Punctati-sporites,* and *Raistrickia*. Mississippian assemblages from the U.S.S.R. are more like those found in the U.S.A. than those from Scotland.

The few samples of Lower Mississippian rocks the writers have had the opportunity to examine for microfossils have been practically barren of plant spores. *Endosporites* has been identified from sediments of this age, along with some indefinite forms. *Tasmanites* is found in rocks of Lower Devonian to Lower Mississippian age.

The Upper Mississippian has yielded abundant spore types. The genera *Tripartites* and "Grandispora" may be restricted to the Mississippian. *Denso-sporites* is common in Upper Mississippian and Lower Pennsylvanian rocks. Many species of *Endosporites* in the Mississippian are characterized by fine folds of the bladder, which radiate from the spore body. *Knoxisporites* is present in Upper Mississippian and Lower Pennsylvanian strata. *Schulzospora* occurs in the Hardinsburg and Waltersburg formations of the Chester series, while *Triquitrites* has been noted from the Hardinsburg.

Spherical forms of Apiculati with large crowded processes seem to be common in Upper Mississippian and Lower Pennsylvanian sediments. The absence or very rare occurrence of monolete spores is characteristic of Mississippian rocks, although they are abundant in the Pennsylvanian.

Cristatisporites, found in rocks of Upper Devonian to Upper Pennsylvanian age, seems to have its best development in Upper Mississippian time. "Auroraspora" has not been noted from sediments of other than Upper Mississippian and Lower Pennsylvanian age. *Rotaspora?* has been recorded from the Cretaceous of Germany (Thompson and Pflug, 1953), but in the United States it appears to be restricted to Upper Mississippian rocks.

Cirratriradites, Granulati-sporites, Reticulati-sporites, Lycospora, Raistrickia, Punctati-sporites and other spherical forms have long geologic ranges extending from the Upper Devonian (or older) to Recent, and are well represented in the Mississippian.

PENNSYLVANIAN

As a result of the extensive work done in the correlation of Pennsylvanian coal beds by means of spores, more is known of the spores of this age in the U.S.A. and abroad than of those from other periods of the Paleozoic. (For a historical summary, see Schopf, Wilson and Bentall, 1944.)

Denso-sporites, noted by the writers in one sample from uppermost Pennsylvanian(?) rocks of West Texas, has not been reported from Pennsylvanian sediments above the lower part of the Des Moines series elsewhere in North America. This genus reached its maximum development in the Upper Mississippian and Lower Pennsylvanian.

Cirratriradites, found in Devonian to Recent sediments, is important stratigraphically within the Pennsylvanian system. The writers have found that the

genus includes two distinct morphologic groups. One form is characterized by its small size (50μ or less) and narrow, thin flange. The other form is larger (76μ or more), has a thicker and broader flange, and usually exhibits prominent markings on the central distal surface. The small form is very abundant in Lower Pennsylvanian and Upper Mississippian rocks. In North America, the larger form has not been noted above the lower part of the Des Moines series nor below the Upper Devonian series, and is seldom found in abundance. In Europe the stratigraphic range of the genus seems to be in agreement with its North American occurrence.

Schulzospora (under the name *Zonotriletes campylopteris*) has been noted by Luber and Waltz from Lower Carboniferous coals of the Karaganda basin in the U.S.S.R. It is common in the Waltersburg and Hardinsburg formations of the Chester series and in Lower Pennsylvanian rocks of Illinois and Alabama.

Illinites appears to have a limited range in Illinois, occurring only in and above the Shoal Creek coal (McLeansboro series). A similar form, described by Schemel in 1951 as *Vesicaspora*, occurs in the Mystic, Cherokee and Marmaton coals (upper Des Moines series). The writers have observed species of *Illinites* (and *Vesicaspora*) from Texas Pennsylvanian rocks of the Cisco series, and some doubtful forms from the Canyon series. *Illinites* has been reported from the Westfalian C of Europe.

Knoxisporites, found by the authors in the Hardinsburg formation of Upper Mississippian age, has also been recognized by them in Pottsville coals of Alabama. The genus appears to be a good marker for Upper Mississippian and Lower Pennsylvanian rocks. Monolete spores, common in Cenozoic and Mesozoic rocks, are abundant in Middle Pennsylvanian sediments. A single specimen (contaminant?) was reported from the Daggett coal of Upper Mississippian age from Utah. They are common in some of the Pottsville coals of the Warrior Basin, Alabama. Some forms similar to *Latosporites* have been discussed in the section on Devonian rocks.

The genus *Cadiospora*, while rather rare and noted only from the Illinois basin, may be a useful guide fossil, since it occurs there only in McLeansboro rocks.

The genera *Wilsonia*, *Florinites*, *Alati-sporites* and *Schopfites* appear to have their first occurrence in Pennsylvanian strata and, with the exception of *Florinites*, may be restricted to rocks of this age. *Florinites* is present in Stanley rocks (Springer series). An unpublished genus of Stanley age is "Radiaspora," a circular trilete spore with numerous radial ribs on the distal surface (pl. 3, fig. 7).

Reinschospora, noted only from Pennsylvanian rocks of North America (Illinois, Pottsville of Alabama), has been described from Lower Carboniferous coals of the U.S.S.R.

PERMIAN

Nothing has been written on Permian plant spores of the Western Hemisphere. There are a few papers on those of India, the U.S.S.R., and Australia. Virkki (1938) found numerous spores in the Lower Gondwana rocks of the Salt Range, Punjab, including two-winged pollen similar to *Pityosporites antarcticus* Seward, suspected by Seward to be a pollen grain of *Glossopteris*. Virkki also examined shale from the Permo-Carboniferous of Newcastle, New South Wales, and found very similar grains *(Pityosporites sewardi)* associated with *Glossopteris browniana*. Ghosh and Sen (1948) illustrated and informally described several types from the coal seams of the Raniganj field of Bengal. They found *Pityosporites*, a double-winged pre-pollen, the predominant form. In higher beds (Panchet), the number of species declines. This is true also of the *Glossopteris* assemblage. They record that "the dominance of *Pityosporites* [*Lueckisporites* Potonié and Kremp in part] in Raniganj coals strongly indicates that the seams are mainly derived from *Pityosporites*-bearing plants, viz., probably *Glossopteris*." Other spores illustrated by Ghosh and Sen include species of *Punctati-sporites, Apiculati-sporites, Verrucosi-sporites, Plani-sporites, Granulati-sporites, Lophotriletes*, a single-bladdered form, *Laevigato-sporites*, and a few of unknown type. Goswami (1951, 1952) considered microfossils from the Gondwana of Rewah (India); Surange, Singh, and Shrivastava (1953*a*, *b*) and Tripathi (1952) worked with Lower Gondwana spores.

Naumova (1937) illustrated eight spores and pollen from the Permian of Siberia. These include *Punctati-sporites*, two forms with girdles or single bladders, *Entylissa* (cycad?) pollen, and three trilete deltoid forms bearing spinose processes. Luber (in Goubkin, 1938) described several Permian forms from the Kuznetsk basin, U.S.S.R., including *Denso-sporites, Endosporites, Granulati-sporites, Laevigato-sporites, Raistrickia*, and several uncertain specimens including cycad-like forms, a two-bladdered form, and a single-bladdered form.

Spore genera recorded by the authors from the upper Cisco (Pennsylvanian) or lower Wolfcamp (Permian)

of North Texas include *Cirratriradites, Illinites, Granulati-sporites, Endosporites, Florinites, Lophotriletes, Raistrickia, Laevigato-sporites, Cristati-sporites, Punctati-sporites, Plani-sporites, Verrucosi-sporites, Apiculati-sporites, Denso-sporites(?),* monocolpate cycad-like forms (*Entylissa* or *Cycadopites*), and two-bladdered forms. Wolfcamp and Leonard rocks from the same area contain definite specimens of *Lueckisporites, Illinites(?), Pityosporites, Florinites,* and numerous forms with spines, apiculae, and granules.

CHARTS OF GEOLOGIC RANGES

The charts represent North American spore ranges obtained from the literature and from the work at the Carter Oil Research Laboratory in Tulsa. Ranges of some of the genera are in doubt.

A valid criticism of spore range-charts is that the few papers thus far published could represent, statistically, only a few environments (especially the coal swamp). The authors believe, however, that the status of knowledge on ranges of small-spore genera in North America should be brought out at this time.

APPENDIX

The following is that portion of the system of classification used by Potonié and Kremp (1954) pertaining to small spores (micro- and isospores) only. The geologic ranges given cover Eurasia only. Critical comments by the authors of the present paper are enclosed in brackets.

SPORITES H. Potonié 1893

Division TRILETES Reinsch 1881

Subdivision Azonotriletes Luber 1935

Suite Laevigati (Bennie and Kidston 1886)

Leiotriletes (Naumova 1937): Trilete, subtriangular, outline smooth, surface levigate to infrapunctate or infragranulate. *L. Sphaerotriangulus* (Loose). Basal Tournaisian — Lower Permian.

Punctati-sporites (Ibrahim 1933): Trilete, circular, exine punctate to infrareticulate or infragranulate (outline smooth), trilete ray usually exceeds half the radius, contact areas absent. *P. punctatus* Ibrahim. Basal Tournaisian — Lower Permian.

Punctata-sporites Ibrahim 1933: Trilete rarely recognizable, exine often thin and finely infragranulate to maculate or structureless, contact areas absent. *P. sabulosus* Ibrahim. [There is little justification in separating these forms from *Punctati-sporites*. The distinction is useable only on a specific level.] Russia, Tournaisian — Visean; Europe, Westphalian B.

Calamospora Schopf, Wilson and Bentall 1944: Trilete, circular, thin-walled, contact areas often present, exine without structure (rarely a slight internal punctation), trilete rays short, secondary taper-point folding often present. *C. hartungiana* Schopf 1944. [Thick-walled megaspores of calamitalean origin should perhaps be separated from this genus.] Basal Tournaisian — Lower Permian.

Granulati-sporites (Ibrahim 1933): Trilete, subtriangular, exine densely granulose, granules rather spherical and of approximately equal size overall. *G. granulatus* Ibrahim. Basal Tournaisian — Lower Permian.

Cyclogranisporites Potonié and Kremp: Trilete, circular, exine similar to *Granulati-sporites*. *C. leopoldi* (Kremp 1952). Upper Namurian—Upper Stephanian.

Suite Apiculati

Plani-sporites (Knox 1950): Trilete, circular; very small cones densely arranged overall, approximately equal in size and development, height approximates diameter of base. *P. granifer* (Ibrahim) Knox. [We have seen triangular forms with this ornamentation.] Visean — Lower Permian.

Apiculati-sporites (Ibrahim 1933): Trilete, circular; thickly covered with tapered cones whose basal diameter can equal their height, more or less variable in size, so closely crowded that their bases may touch. *A. aculeatus* Ibrahim. Basal Tournaisian — Lower Permian.

Lophotriletes (Naumova 1937): Trilete, subtriangular, otherwise similar to *Apiculati-sporites*. *L. gibbosus* (Ibrahim). Basal Tournaisian — Lower Permian.

Anapiculatisporites Potonié and Kremp 1954: Trilete, circular to convexly subtriangular; proximal surface smooth, distal surface with cones or spines (similar to those of *Apiculati-sporites* and *Acanthotriletes*). Resembles *Schopfites*. *A. isselburgensis* Potonié and Kremp. Top Westphalian A through Westphalian C.

Acanthotriletes (Naumova 1937): Trilete, ciliate; spines closely crowded, attenuate, longer than twice their diameter; the greater length of spines, their attenuation and often sharper tips distinguish them from the processes of *Lophotriletes* and *Apiculati-sporites*. *A. ciliatus* (Knox). Upper Tournaisian — Lower Permian.

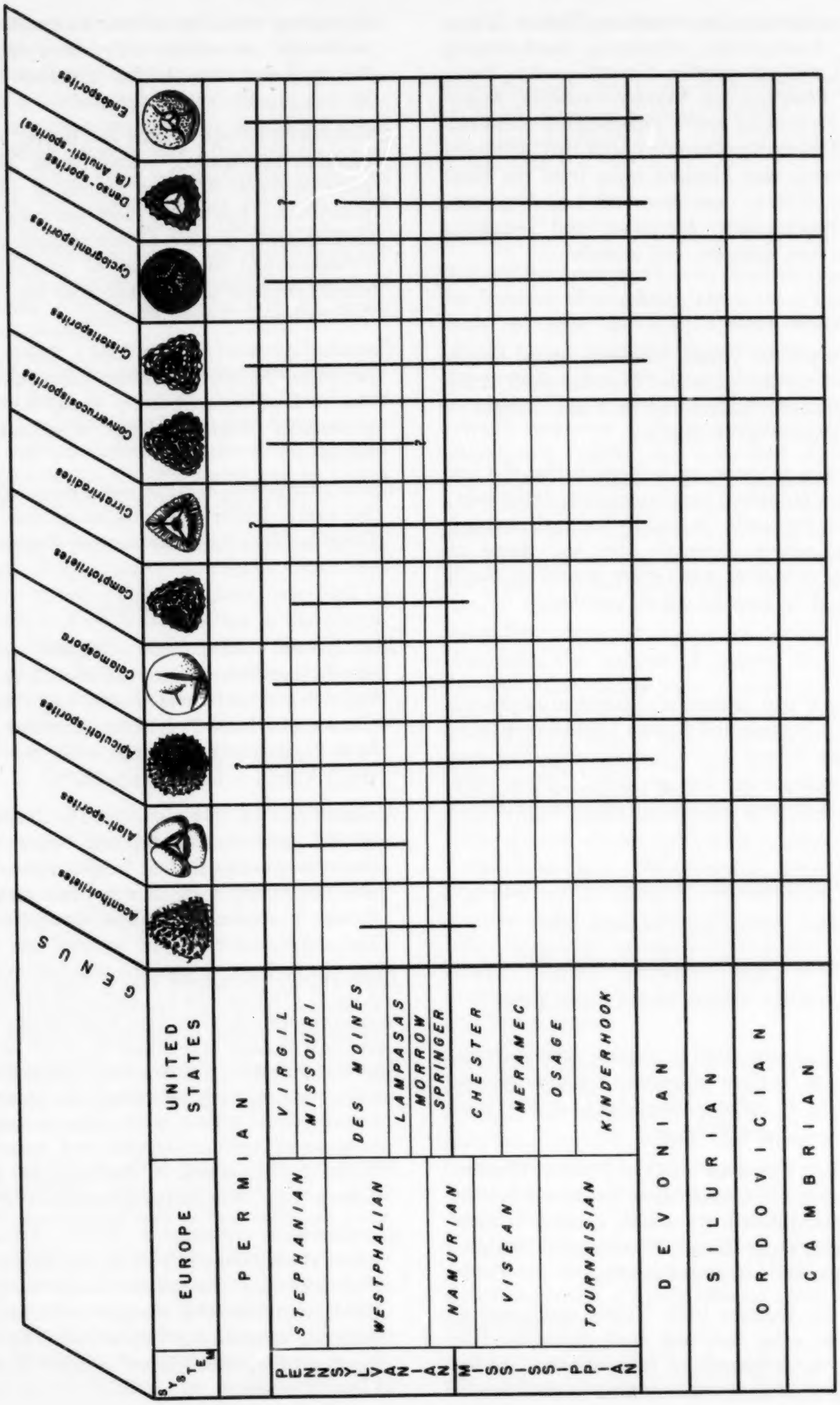

CHART 1
RANGES OF PALEOZOIC PLANT-SPORE GENERA

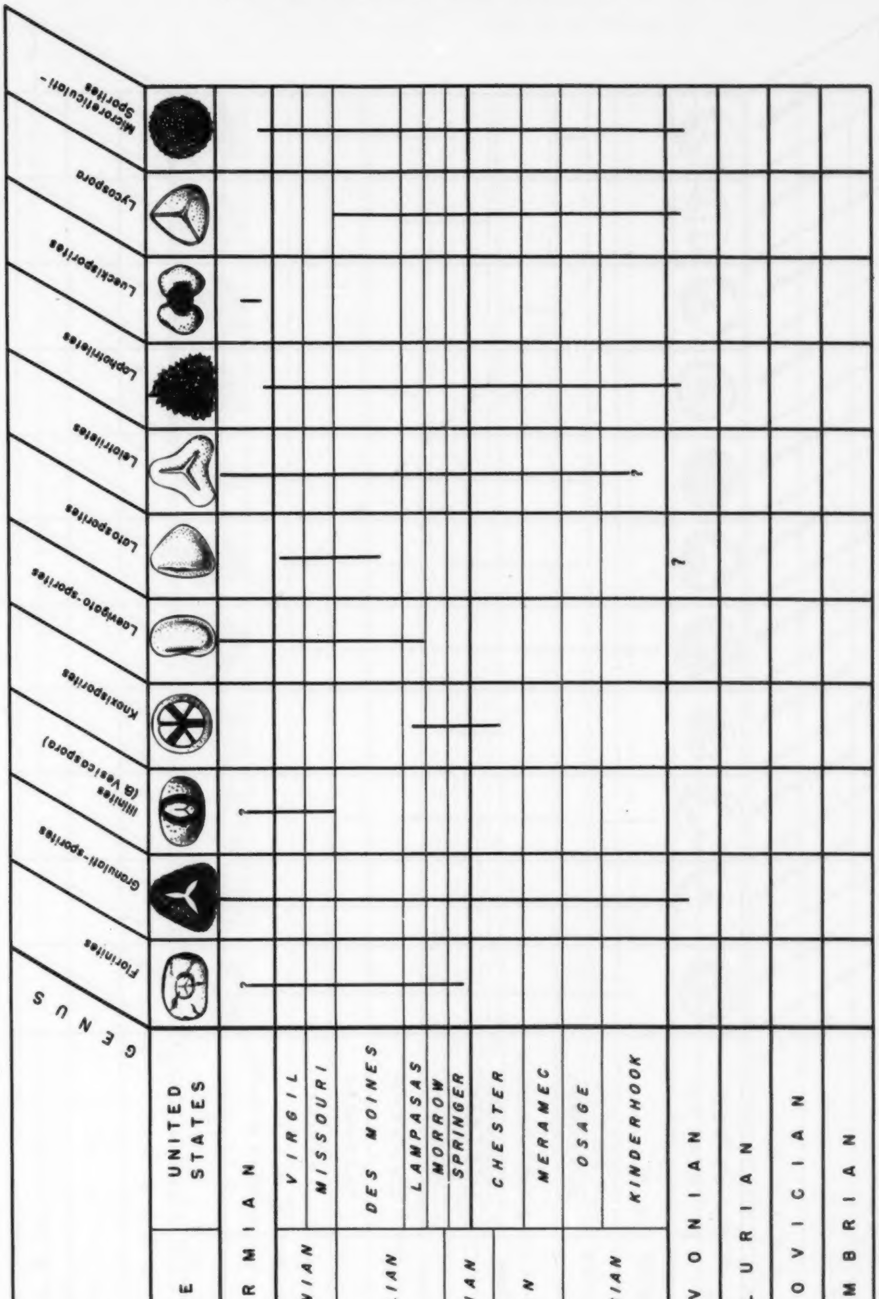

CHART 2

RANGES OF PALEOZOIC PLANT-SPORE GENERA

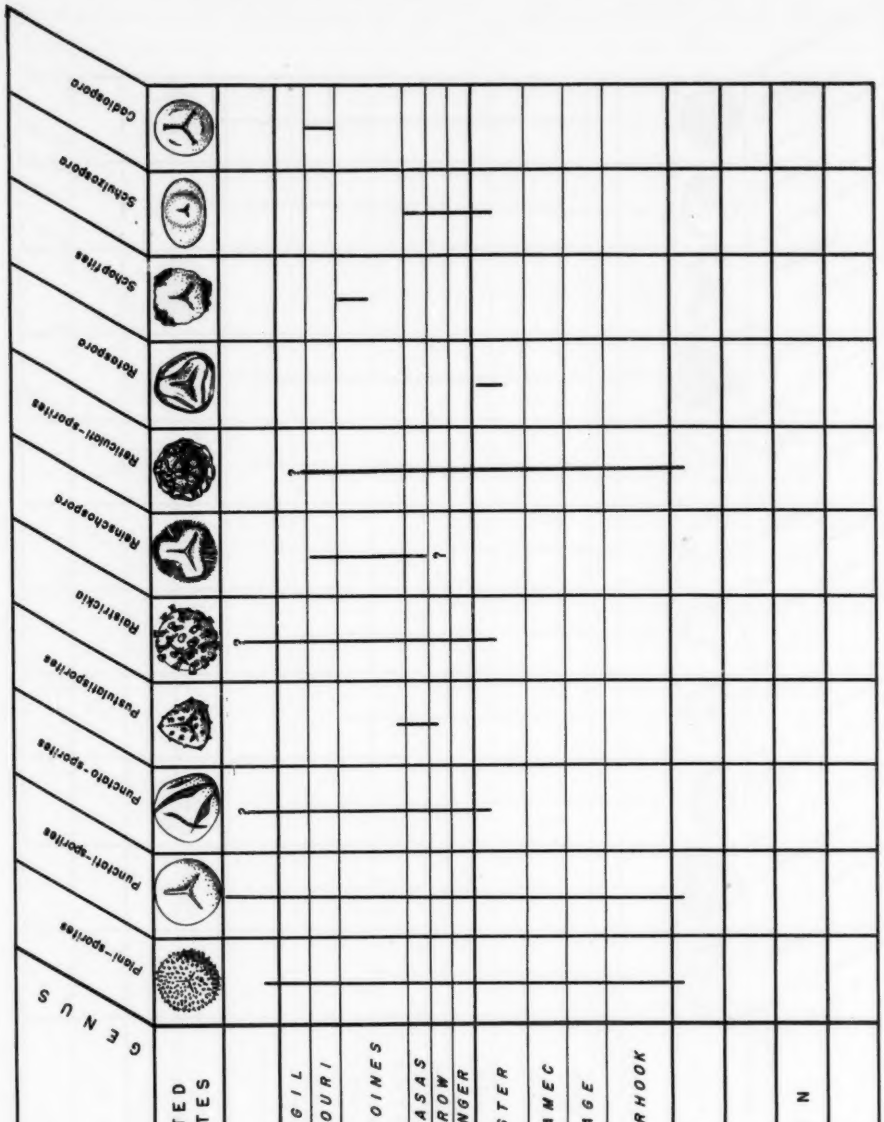

CHART 3
RANGES OF PALEOZOIC PLANT-SPORE GENERA

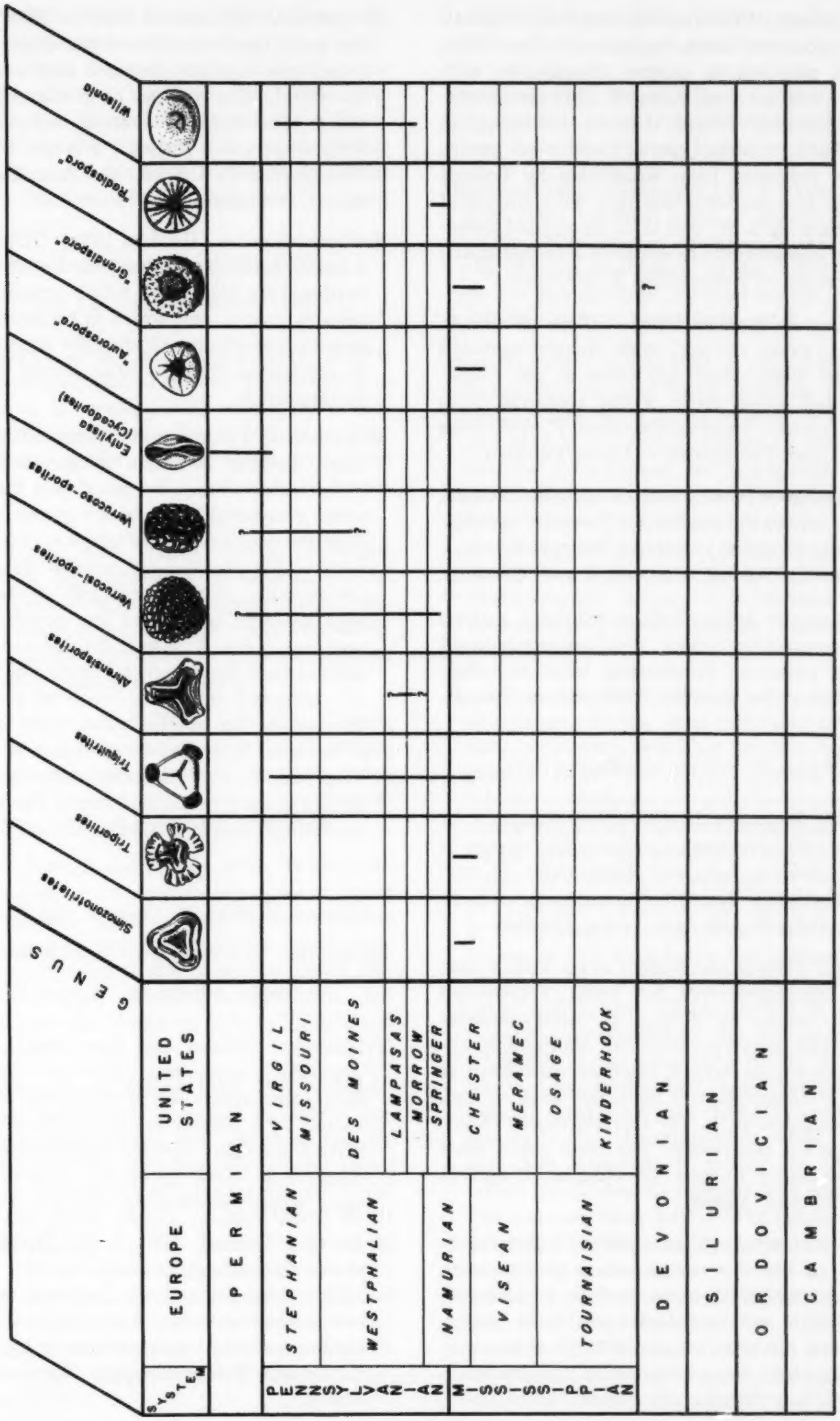

CHART 4
RANGES OF PALEOZOIC PLANT-SPORE GENERA

Raistrickia (Schopf, Wilson and Bentall 1944): Trilete, circular; processes large, cylindrical, tips often broadened, papillate, or partate; interspersed with the baculae may be small cones or other ornamentation. *R. grovensis* Schopf. [Forms belonging to *Acanthotriletes, Apiculati-sporites,* and other genera have been separated from *Raistrickia* by Potonié and Kremp. It is doubtful that they were embraced within *Raistrickia* S. W. and B. in its original definition, hence emendation has not been accomplished.] Basal Namurian — Westphalian B (Europe).

Verrucosi-sporites (Ibrahim 1933): Trilete, circular to subcircular, exine covered with thickly crowded broad-based warts which are more or less irregularly rounded, never more or less spherical as in *Granulati-sporites,* sometimes arcuate. *V. verrucosus* Ibrahim. Upper Tournaisian — Lower Permian.

Converrucosisporites Potonié and Kremp 1954: Trilete, triangular, otherwise similar to *Verrucosi-sporites. C. triquetrus* (Ibrahim). Europe, Westphalian A — Westphalian C; U.S.S.R. and Asia, Lower Permian.

Schopfites Kosanke 1950: Trilete, proximal surface largely or completely levigate, distal surface covered with large, crowded, imbricating, blunt to round warts. *S. dimorphus* Kosanke. Unknown in Eurasia.

Suite Muronati Potonié and Kremp 1954

Camptotriletes Naumova 1937: Trilete, sculpture of formless knobby processes (rudimentary cristae or ridges, irregular in form and disposition). *C. corrugatus* (Ibrahim). Europe, Namurian A — Westphalian C; U.S.S.R. and Asia, Lower Permian.

Cristatisporites Potonié and Kremp 1954: Trilete, surface like *Apiculatisporites,* but bases of processes fused into cristae or ridges. *C. indignabundus* (Loose). [The genotype, from the photograph, appears to be a zonate form. It has been considered as a species of *Denso-sporites* by many workers and, if not *Denso-sporites,* is still an unfortunate choice as genotype for this reason. The form genus itself is a useable unit.] Europe, Westphalian B and C; U.S.S.R. and Asia, Visean.

Microreticulati-sporites (Knox 1950): Trilete, subtriangular to circular, exine extrareticulate with small lumina which do not exceed 6μ in diameter, muri imperfect and branched, variable in height. *M. lacunosus* (Ibrahim) Knox 1950. [Lumina may slightly exceed 6μ — up to 8μ to 9μ.] Upper Tournaisian — Lower Permian.

Dictyotriletes (Naumova 1937): Trilete, reticulate, the gross mesh-structure of the exine surface is not raised into high membranous muri as in *Reticulati-sporites,* lumina shallow. *D. mediareticulatus* (Ibrahim). [Drawings by Potonié and Kremp show a levigate proximal surface.] Europe, Namurian A — Westphalian C; U.S.S.R. and Asia, Upper Tournaisian — Westphalian A(?).

Reticulati-sporites (Ibrahim 1933): Trilete, exine with a heavy net-like sculpture, lumina of the reticulum bordered by high muri, which appear in section as tines or prongs, and which in transverse section appear as a membrane binding the tines to each other. *R. reticulatus* Ibrahim 1933. Upper Tournaisian — Stephanian A.

Knoxisporites Potonié and Kremp 1954: Trilete, circular, bearing triradiate thickened bands on the distal surface which are fused to a thickened equatorial peripheral band, bands generally rotated 60° from the positions of the trilete rays of the proximal surface, peripheral band usually distal to equator. Occasionally, at the distal pole where the thickenings converge, a more or less circular unthickened area may occur. *K. hageni* Potonié and Kremp. [The authors have found several species of this genus. In all, thickened extensions from the peripheral band enclose the tips of the trilete rays. Ornamentation of the spore body may be present, and the peripheral band may develop additional unthickened areas and membranous extensions or muri.] Europe, Namurian A—Westphalian B; U.S.S.R. and Asia, Westphalian D.

Division ZONALES (Bennie and Kidston 1886)

Subdivision Auritotriletes Potonié and Kremp 1954

Suite Auriculati (Schopf 1938)

Triquitrites (Wilson and Coe 1940): Trilete, subtriangular, auriculate; auriculae thickened and darker than remainder of spore coat, sometimes connected by a narrow equatorial flange. *T. arculatus* Wilson and Coe. [Species with spinose auriculae are common in some American coals of Des Moines age.] Upper Tournaisian — Lower Permian.

Tripartites Schemel 1950: Trilete, subtriangular; auriculae broadened, lobulate (fluted), often radially folded, normally connected to each other by a narrow equatorial flange. Auriculae in *Triquitrites* are smaller and cushion-shaped, never broad and fluted. *T. vetustus* Schemel. Upper Tournaisian — Namurian A.

Ahrensisporites Potonié and Kremp 1954. Trilete, subtriangular, radial corners with swellings from which emanate crescentic bow-like folds (kyrtome), the middle parts of which approach the distal polar area of the spore, the arches (kyrtome) are therefore absent from the equator. The radial corners form the tangents of the three arches. *A. guerickei* (Horst 1943). Namurian A—Westphalian (Europe).

Subdivision ZONOTRILETES (Waltz 1935)

Suite CINGULATI Potonié and Klaus 1954(?)

Lycospora (Schopf, Wilson and Bentall 1944): Trilete, with cingulum (equatorial girdle) appearing as a cuneiform ring in cross-section, central body levigate, infragranulate or granulate, trilete rays clear, extended almost to the equator. *L. micropapillata* (Wilson and Coe). Upper Tournaisian — Lower Permian.

Cadiospora Kosanke 1950: Trilete, strongly developed arcuate ridges, lips extremely prominent, in the genotype the rays divide at their termini and interradially become the arcuate ridge, spore coat thick. *C. magna* Kosanke. [The above diagnosis abstracted from Kosanke.] Unknown in Eurasia.

Anguisporites Potonié and Klaus 1954(?): Trilete, cingulate, regularly undulating tetrad mark, cingulum a narrow, more or less massive equatorial ring with cuneiform cross-section. *A. anguinus* Potonié and Klaus. [In press. Questionably Paleozoic.]

Galeatisporites Potonié and Kremp 1954: Trilete, cingulate, cingulum formed from heavy cones or spines which have grown together basally; contact areas more or less smooth, occupy almost the entire proximal surface, reaching to the cingulum; distal surface provided with tuberculate processes, not crowded. *G. galeatus* (Imgrund 1952). U.S.S.R. and Asia, Stephanian B and C.

Mirisporites Potonié and Kremp 1954: Trilete mega- or microspores with heavy cingulum, equatorial outline very irregularly sinous but otherwise smooth, on the interior of the cingulum are several radial tenons (on the genotype) which give support to the cingulum, the radial tenons proceed from an irregular but sharply limited darker zone which surrounds the convexly triangular central body nearest the cingulum, an outer brighter zone of the cingulum spanning the tenons appears rather membranous. *M. luxi* Potonié and Kremp. U.S.S.R. and Asia, upper Tournaisian — Visean; Europe, Westphalian C(?).

Rotaspora Schemel 1950: Trilete circular microspores with rather broad and smooth cingulum, thickened at periphery to form a narrow rim, central body subtriangular, the circular cingulum narrower at the radial corners, central body usually infragranulate. *R. fracta* Schemel. Namurian A (Europe).

Simozonotriletes (Naumova 1937): Trilete, trilete rays very sharp, reaching more or less to the cingulum, outline subtriangular, cingulum broad, smooth, usually broader (or higher) at the radial corners, concave or straight-lined between the corners. *S intortus* (Waltz 1938). Upper Tournaisian — Namurian B.

Anulati-sporites (Loose 1934, p. 151, footnote): Trilete, equatorial cingulum broad, relatively high, massive, sculptureless, often brown in color, at least as broad and high at the radial corners as interradially; interradial sides convex; peripheral edge of cingulum rather strongly rounded, not always tapered; sometimes with a few places of fracture; central body smooth to infrapunctate, trilete rays indistinct to perceptible. *A. anulatus* (Loose). [See note under *Denso-sporites*, below.] U.S.S.R. and Asia, upper Tournaisian — Visean; Europe, Visean(?) — Westphalian C.

Denso-sporites (Berry 1937): Trilete easily recognizable in most forms, often extending into the cingulum, sometimes reaching to the equator, often gnarled. Exine thin in polar regions but increases rapidly in thickness toward the equator, by which means originates the cuneiform massive cingulum which clasps the equatorial region of the spore rather far polewards, like a gable. The cingulum is in its structure more or less shelly, often exfoliated at the equatorial edge, often possessing a radially striate as well as more or less infragranulate inner structure. The sculpture can be small verrucae to cones and spines. *Denso-sporites* is distinguished from *Anulati-sporites* by the distinct structure and sculpture of the cingulum, which is always completely sculptureless in *Anulati-sporites*. The central area of *Anulati-sporites* shows at most weak infrapunctation to infragranulation, while distinct structure and sculpture is shown by *Denso-sporites*, which can be heavily charged with warts and cones. (*D. covensis* Berry 1937.) [The presence of a strong trilete, a differentiated cingulum, and heavy ornamentation in *Denso-sporites* serves to distinguish it from *Anulati-sporites*. Difficulties are foreseen for this usage, because specimens of some extremely variable species may or may not possess a strong trilete, and may or may not have a differentiated cingulum. Many other types of differentiation of

the cingulum are known besides those listed by Potonié and Kremp. A transitional(?) sequence of *Cirratriradites — Denso-sporites — Anulati-sporites* types is suspected by L. R. Wilson and others. A circular form with broad heavy cingulum and strong trilete is also known (pl. 2, fig. 2).] U.S.S.R. and Asia, upper Tournaisian — Visean; Europe, Visean — Westphalian D.

Suite ZONATI Potonié and Kremp 1954

Cirratriradites (Wilson and Coe 1940): Trilete, zonate; the flange broad, membranous, equatorial; trilete rays strong, often extended to the outer edge of the flange. *C. saturni* (Ibrahim) Schopf, Wilson and Bentall. [The flange is often striate, and prominent scar-like markings are sometimes present on the central distal surface. Wilson and Coe's genotype is *C. maculatus,* which was placed in synonomy with *C. saturni* by Potonié and Kremp. Unless direct comparisons of the two types have been made, this procedure is questionable.] Upper Tournaisian — Westphalian D.

Reinschospora Schopf, Wilson and Bentall 1944: Trilete, subtriangular, corners rounded. A radially striated zone composed of fimbriae, either free or more or less fused, clothes the equator. The zone is broadest in the middle of the interradial sides, and may be absent at the corners. *R. speciosa* (Loose) Schopf, Wilson and Bentall, syn. *R. bellitas* Bentall 1944(?). U.S.S.R. and Asia, upper Tournaisian — Visean; Europe, Westphalian A and B.

Division MONOLETES Ibrahim 1933

Subdivision AZONOMONOLETES Luber 1935

Laevigato-sporites Ibrahim 1933: Monolete, levigate to infrareticulate, equatorial outline broadly oval to approximately circular, distal surface in section a weak circular arch, never angled distally as in *Latosporites,* polar axis therefore relatively shorter than in *Latosporites.* Exine always without sculpture, monolete suture straight. *L. vulgaris* Ibrahim. Namurian A — Lower Permian.

Latosporites Potonié and Kremp 1954: Monolete, structure levigate to infrareticulate, equatorial outline broadly oval to approximately circular, distal surface in section a curve which is strongly arched in the central distal area (not an evenly curved circular section). *L. latus* (Kosanke 1950). [Distal surface produced and bluntly angled. The genotype does not appear to have this characteristic, but is merely very broad in the plane at right angles to the monolete mark. The usefulness of this genus is doubtful.] Namurian C — Lower Permian.

Punctato-sporites Ibrahim 1933: Monolete, shape similar to *Laevigato-sporites,* but outline rough because of the overall granulosity of the exine. *P. minutus* Ibrahim 1933. Westphalian(?) — Lower Permian.

Verrucoso-sporites (Knox 1950): Monolete, shape similar to *Laevigato-sporites,* but exine covered overall with verrucae. *V. obscurus* (Kosanke 1950). Lower Permian (U.S.S.R. and Asia only.)

Tuberculato-sporites Imgrund 1952: Monolete, shape similar to *Laevigato-sporites,* but exine covered overall (not too densely) with cones or spines, or loosely arranged warts. If the warts are densely packed, then the forms belong to *Verrucoso-sporites. T. anicystoides* Imgrund 1952. Lower Permian (U.S.S.R. and Asia).

Torispora Balme 1952: Monolete. Flattened specimens have a pear- to acorn-shaped outline. Exine outside of the central proximal surface strongly thickened and therefore appears essentially darker than that of the constricted proximal part of the spore, on which, following the longest axis, the monolete mark is found. *T. securis* Balme 1952. Westphalian C and D (Europe only).

Subdivision ZONOMONOLETES Potonié and Kremp

Speciososporites Potonié and Kremp 1954: Monolete. Equatorial outline oval, with distinct cingulum. Exine granulose, finely verrucose, microreticulate. Monolete more or less extended, often weakly raised since the proximal surface is somewhat arched. *Pericutosporites* has a broader, often more membranous cingulum. *S. bilateralis* (Loose). U.S.S.R. and Asia, Lower Permian; Europe, Westphalian B through D.

Pericutosporites Imgrund 1952: Monolete. Equatorial outline oval, more or less uniform in section, the zone around the equator more or less membranous, sinuous. *P. potoniei* Imgrund 1952. Lower Permian.

Pectosporites Imgrund 1952: Monolete, spindle-shaped equatorial outline. Distal area more or less crescentically swelled out. Proximal surface framed by a crested cingulum, which consists of two ridges, which are more or less parallel and then converge, whose interval is often rather slight, and which border an area on the proximal surface. *P. qualiformis* Imgrund. Stephanian C — Lower Permian (U.S.S.R. and Asia only).

Subdivision DISACCITES Cookson 1947

Vesicaspora Schemel 1951: *V. wilsonii* Schemel 1951. [Probably a synonym of *Illinites*.] Stephanian C — Lower Permian (Europe only).

Parasporites Schopf 1938: *P. maccabei* Schopf 1938. Unknown in Eurasia.

Illinites (Kosanke 1950) Potonié and Klaus 1954(?): Trilete, bisaccate trilete rays short and often unequal, sometimes indistinct or not recognizable, outline inclusive of bladders oval to elliptical. [Kosanke defines the genus as having a distinct functional trilete, bladders not inclined distally and as wide as the body. We do not recognize that emendation has been accomplished.] Westphalian C (Europe only).

Alisporites Daugherty 1941: *A. opii* Daugherty 1941. Not reported from Eurasia.

Lueckisporites Potonié and Klaus 1954(?): Bisaccate, alete. The infrareticulate bladders pendant distally, therefore in meridional outline there is a greater distance between the air sacs proximally than distally. The more or less smooth and structureless intexine of the central body is covered proximally by a strongly formed infrabaculate exoexine. Proximal surface laesurate (one or more), lasurae parallel to the longest axis of the central body and may reach from one bladder attachment line to the other. The central cleavage resembles a monolete suture. At the distal polar area the exoexine layer is faint. In part *Pityosporites sewardi* Chinna Virkki 1937, p. 428, figs. 1-3; *Glossopteris* form of Ghosh and Sen 1948, p. 74. *L. virkkiae* Potonié and Klaus 1954(?). Upper Permian.

POLLENITES R. Potonié 1931

(Forms not emended or not new are not described.)

Division SACCITES Erdtman 1947

Subdivision POLYSACCITES Cookson 1947
(Forms with three or more bladders.)

Alati-sporites Ibrahim 1933: Trilete. *A. pustulatus* Ibrahim 1933. Westphalian (Europe); Lower Permian (Asia and U.S.S.R.).

Subdivision MONOSACCITES Chitaley 1951

Microsporites Dijkstra 1946 (= *Spencerisporites* Chaloner 1951): *M. karczewskii* (Zerndt) Dijkstra. *Spencerites* is applied to the cones and the spores found in the cones. Europe, Namurian — Stephanian; Asia and U.S.S.R., Namurian — Westphalian.

Nuskoisporites Potonié and Klaus 1954(?): [Not illustrated. In press.] Upper Permian (Europe only).

Endosporites Wilson and Coe 1940: *E. ornatus* Wilson and Coe. Upper Tournaisian to Lower Permian.

Wilsonia Kosanke 1950 (= *Endosporites* in part?): *W. vesicatus* Kosanke 1950. [*Wilsonia, Endosporites,* and "Auroraspora," although not representing the same group of plants, constitute a series ranging from forms with indistinct central body and trilete (*Wilsonia*) to forms with a relatively thick-walled central body, strong trilete, and extremely membranous bladder ("Auroraspora"). All three genera are usable. *Wilsonia* not reported from Eurasia.]

Schulzospora Kosanke 1950: *S. rara* Kosanke 1950. Upper Tournaisian — Namurian A.

Florinites Schopf, Wilson and Bentall 1944: *F. antiguus* Schopf 1944. Westphalian A — Lower Permian.

Pityosporites (Seward 1914) Potonié and Klaus 1954(?): Bisaccate, without or rarely with trilete, bladders infrareticulate, pendant distally, germinal furrow distal, broad, and not sharply limited. *Parasporites* and *Illinites* are always trilete, *Alisporites* has a distinct limited distal sulcus, *Lueckisporites* has one or more proximal lasurae. Permian (Europe only).

Division NAPITES Erdtman 1947

(INAPERTURATES Iverson and Troel-Smith 1950 — ALETES Ibrahim 1933 nomen rejiciend.)

Pollen grains or microspores without visible dehiscence marks.

Division PRECOLPATES Potonié and Kremp 1954

Pollen grains of oval shape, exine exhibiting three long folds following the longest direction of the spore. *Schopfipollenites* is proposed for the pollen of some Medulloseae of the Westphalian of Europe and North America.

Division MONOCOLPATES Iverson and Troel-Smith 1950

Pollen grains in which only one furrow is present, parallel to the long axis of the grain. *Entylissa* (Naumova 1937) is emended for grains similar to those from some Ginkgoales, Cycadales, and Bennettitales(?). *Cycadopites* was proposed by Wodehouse in 1933 for similar pollen in Eocene shales, but no species were described.

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PLATE 1

All figures × 565 unless otherwise noted.

Figure 1 *Latosporites(?)* sp.
Upper Devonian, Alberta; ser. S-167.

2 *Cristatisporites* sp.
Upper Devonian, Alberta; ser. 15354.

3 *Microreticulati-sporites* sp.
Upper Devonian, Alberta; ser. S-171.

4 New genus.
Upper Devonian, Alberta; ser. S-206.

5 *Cirratriradites(?)* sp.
Upper Devonian, Alberta; ser. 15200.

6 New genus.
Upper Devonian, Alberta; ser. S-222.

7 New genus.
Upper Devonian, Alberta; ser. S-123.

8 "Grandispora(?)."
Upper Devonian, Alberta; ser. S-168. × 355.

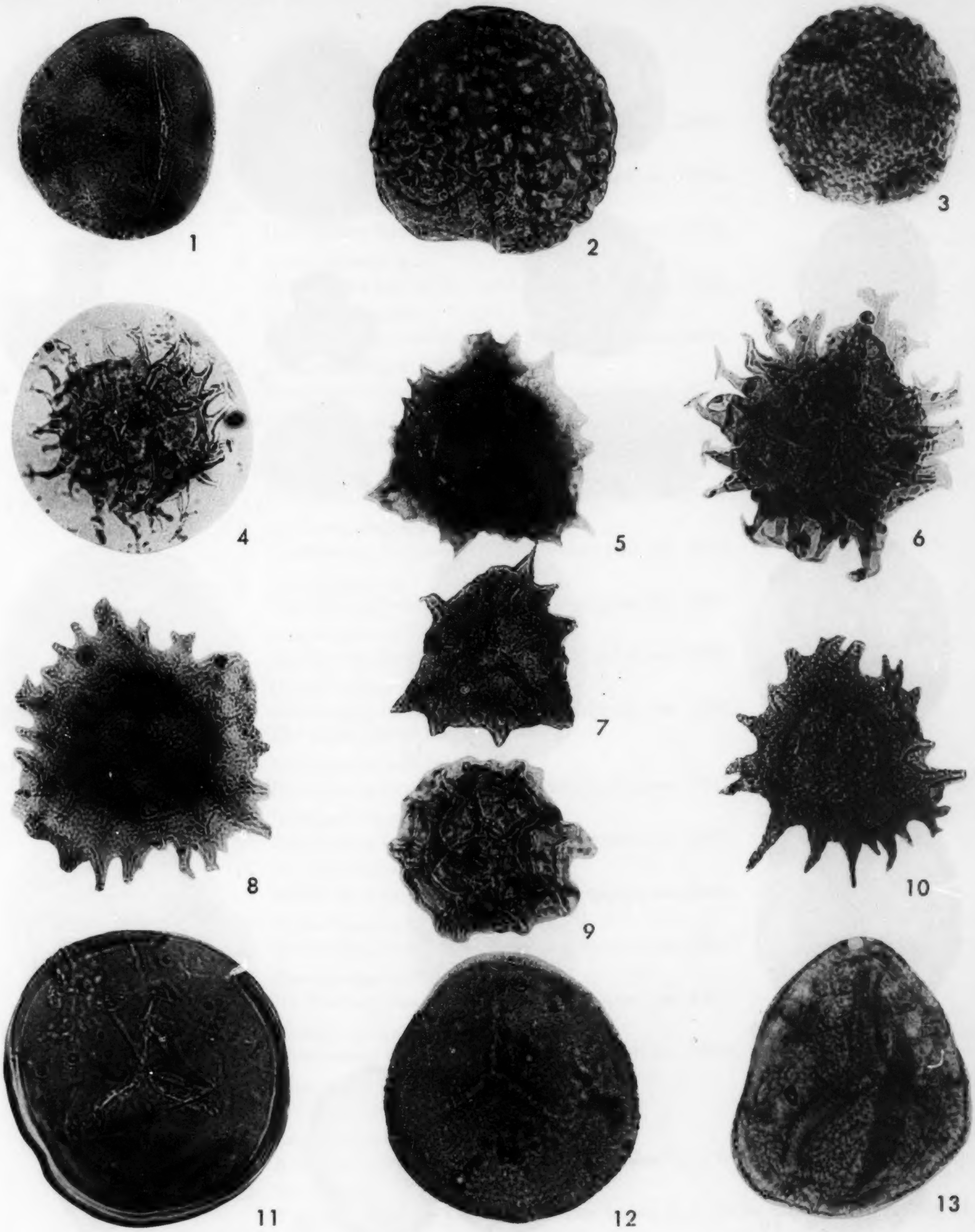
9 *Reticulati-sporites* sp.
Upper Devonian, Alberta; ser. S-183.

10 "Grandispora(?)."
Upper Devonian, Alberta; ser. 15337.

11 *Calamospora(?)* sp.
Upper Devonian, Alberta; ser. S-196.

12 *Cyclogranisporites* sp.
Upper Devonian, Alberta; ser. S-223.

13 *Apiculati-sporites* sp.
Upper Devonian, Alberta; ser. 15330.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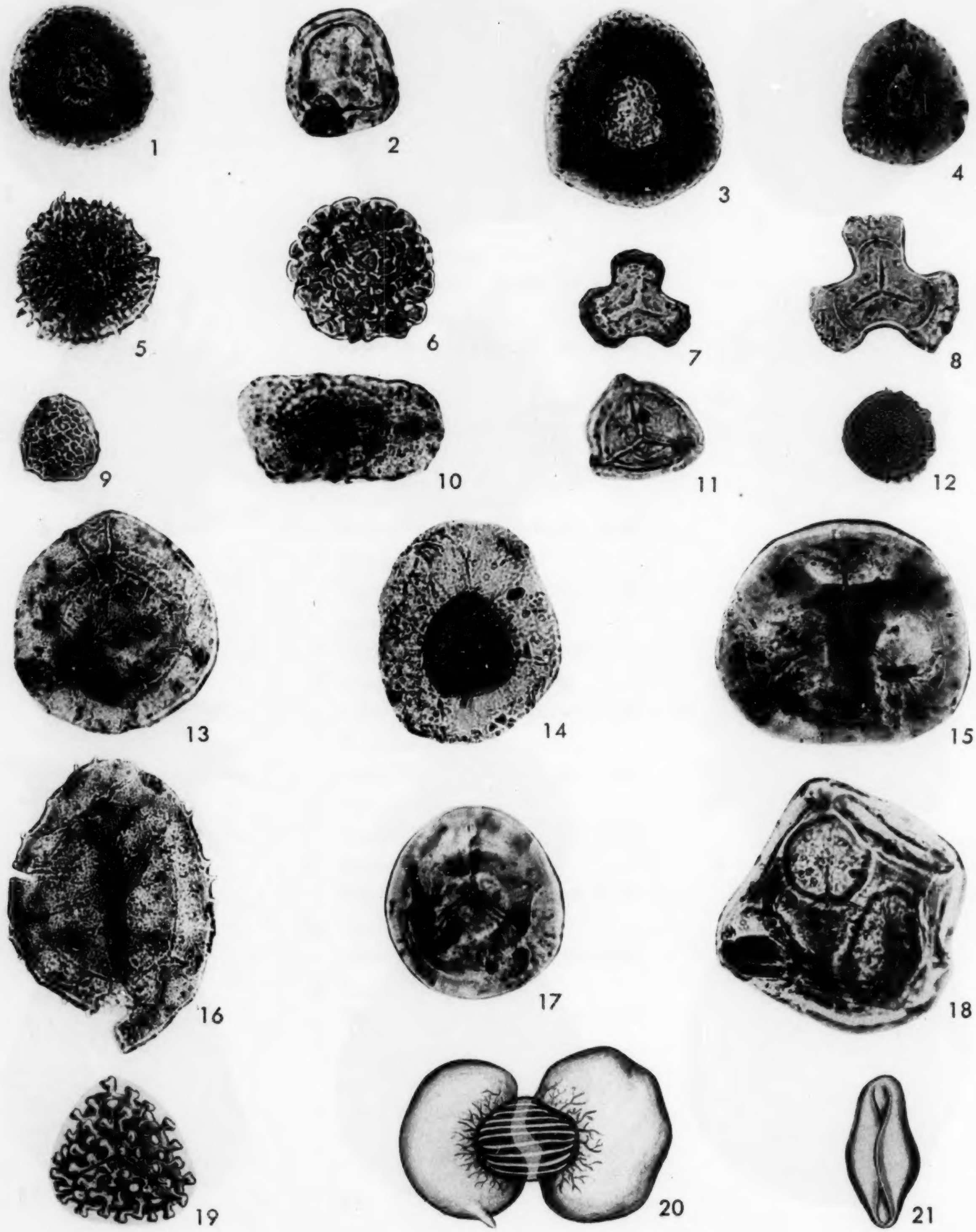

PLATE 2

All figures × 565.

Figure 1 *Denso-sporites* sp. A.
Hardinsburg formation, Upper Mississippian; ser. 18641.

2 *Anulati-sporites(?)* sp.
Hardinsburg formation, Upper Mississippian; ser. 15864.

3 *Denso-sporites* sp. A.
Hardinsburg formation, Upper Mississippian; ser. 18739.

4 *Denso-sporites* sp.
Hardinsburg formation, Upper Mississippian; ser. 18650.

5 *Acanthotriletes* sp.
Hardinsburg formation, Upper Mississippian; ser. 16481.

6 *Cristatisporites* sp.
Hardinsburg formation, Upper Mississippian; ser. 16551.

7 *Triquitrites* sp.
Hardinsburg formation, Upper Mississippian; ser. 15923.

8 *Triquitrites vetustus* Schemel.
Hardinsburg formation, Upper Mississippian; ser. 18807.

9 *Microreticulati-sporites* sp.
Hardinsburg formation, Upper Mississippian; ser. 19396.

10 *Schulzospora* sp.
Hardinsburg formation, Upper Mississippian; ser. 15800.

11 *Cirratriradites* sp.
Hardinsburg formation, Upper Mississippian; ser. 15940.

12 *Cyclogranisporites(?)* sp.
Hardinsburg formation, Upper Mississippian; ser. 19087.
The trilete, shown here, is rare.

13 *Endosporites pallidus* Schemel.
Hardinsburg formation, Upper Mississippian; ser. 19317.

14 "Auroraspora solisortus."
Hardinsburg formation, Upper Mississippian; ser. 19471.

15 *Knoxisporites* sp.
Hardinsburg formation, Upper Mississippian; ser. 18939.

16 "Grandispora spinosa."
Hardinsburg formation, Upper Mississippian; ser. 19033.

17 *Knoxisporites* sp.
Hardinsburg formation, Upper Mississippian; ser. 18672.

18 *Knoxisporites(?)* sp.
Hardinsburg formation, Upper Mississippian; ser. 19884.

19 Spore type.
Typical of many in Permian rocks.

20 *Lueckisporites* sp.
A typical Permian form from India. After Ghosh and Senn, 1948, pl. 3, fig. 1.

21 *Entylissa* sp.
Typical of Permian-Triassic beds. After Luber, in Goubkin, 1938, p. 154, pl. 1, fig. 11.

PLATE 3

All figures × 565 unless otherwise noted.

Figure 1 *Punctati-sporites* sp.
Stanley formation, Oklahoma – Texas; ser. 21382.

2 *Verrucosi-sporites* sp.
Stanley formation, Oklahoma – Texas; ser. 21296.

3 *Verrucosi-sporites* sp., fragment.
Stanley formation, Oklahoma – Texas; ser. 16330.

4 *Endosporites* sp.
Stanley formation, Oklahoma – Texas; ser. 21300.

5 *Cristatisporites(?)* sp.
Stanley formation, Oklahoma – Texas; ser. 22014.

6 *Apiculati-sporites* sp.
Upper Jagger coal, Warrior Basin, Alabama; ser. 20406.

7 "Radiaspora" sp.
Stanley formation, Oklahoma – Texas; ser. 22004.
Numerous radial spoke-like ribs on distal surface.

8 *Florinites* sp.
Stanley formation, Oklahoma – Texas; ser. 21705. × 355.

9 *Florinites* sp.
Stanley formation, Oklahoma – Texas; ser. 13882. × 355.

10 *Pustulatisporites* sp.
Jefferson coal, Warrior Basin, Alabama; ser. 20502.

11 New genus.
Stanley formation, Oklahoma – Texas; ser. 21928.

12 *Denso-sporites* sp.
Blue Creek coal, Warrior Basin, Alabama; ser. 17402.

13 *Cirratriradites* sp.
Blue Creek coal, from well in Mississippi; ser. 17350.

14 *Apiculati-sporites* sp.
Black Creek coal, Warrior Basin, Alabama; ser. 20892.

15 *Schulzospora* sp.
Lower Ream coal, Warrior Basin, Alabama; ser. 20284.

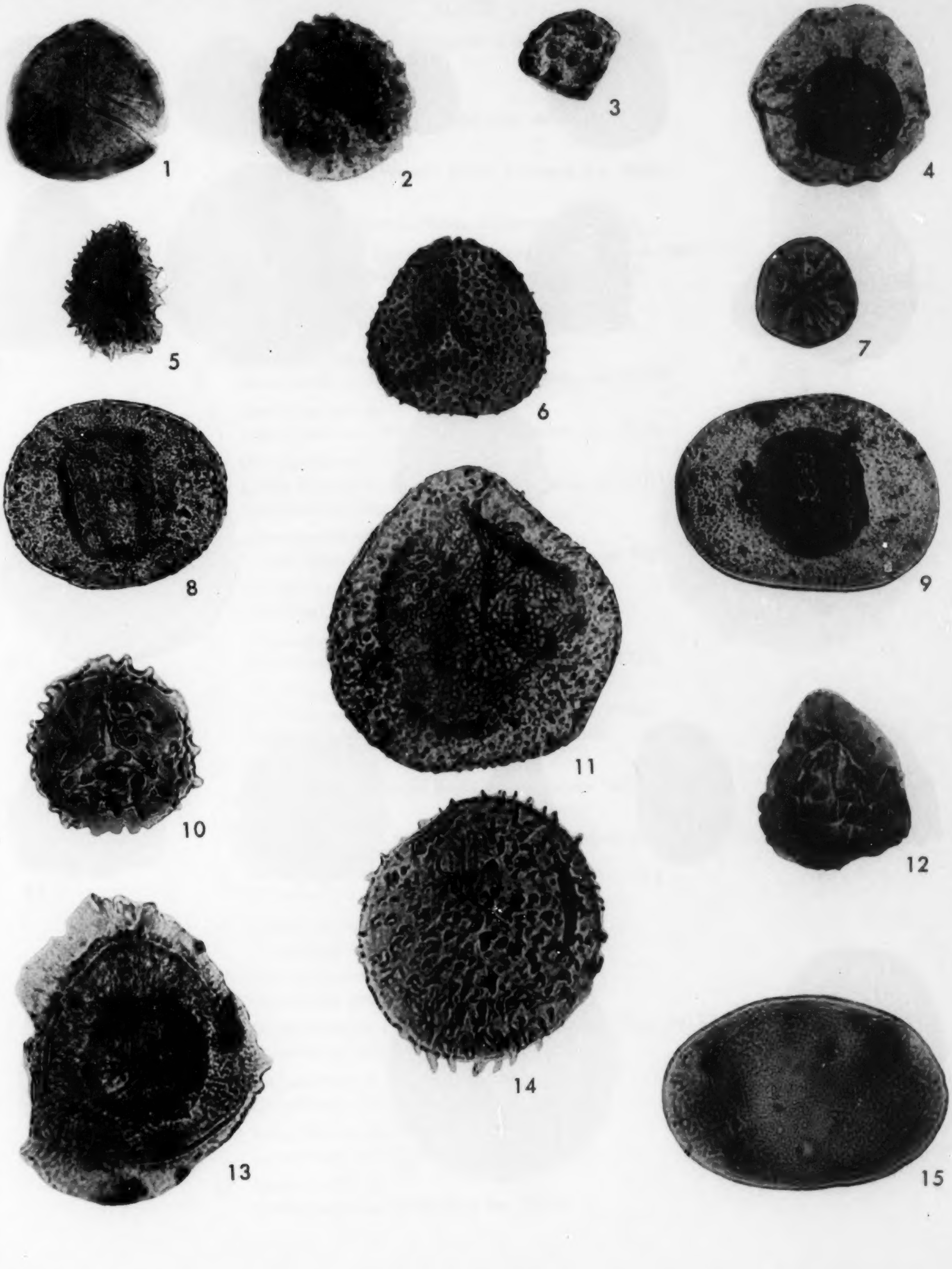
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PLATE 4

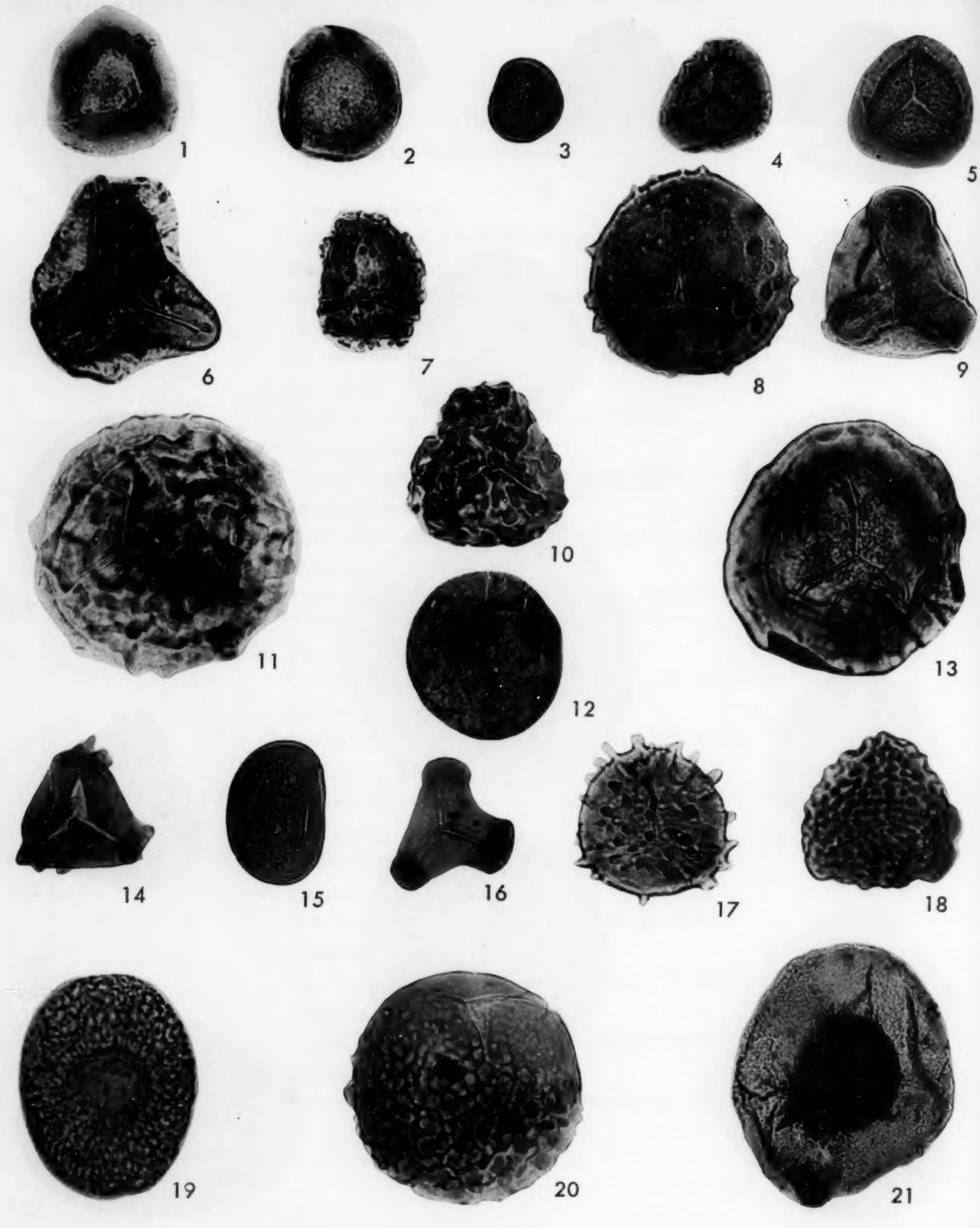

PLATE 4

All figures × 565.

Figure 1 *Denso-sporites* sp.
Cobb coal, Warrior Basin, Alabama; ser. 17764.

2 *Denso-sporites* sp.
Black Creek coal, Warrior Basin, Alabama; ser. 20832.

3 *Lycospora* sp.
Gillespie coal, Warrior Basin, Alabama; ser. 17545.

4 *Cirratriradites*. (*Lycospora pseudoannulata* Kosanke 1950.)
Mary Lee coal, Warrior Basin, Alabama; ser. 17588.

5 *Cirratriradites* sp.
Gillespie coal, Warrior Basin, Alabama; ser. 17742.

6 *Reinschospora* sp.
Black Creek coal, Warrior Basin, Alabama; ser. 20858.

7 *Denso-sporites* sp.
Blue Creek coal, Warrior Basin, Alabama; ser. 17439.

8 *Camptotriletes(?)* sp.
Lower Ream coal, Warrior Basin, Alabama; ser. 20311.
Short serrate ridges and cones.

9 *Ahrensisporites(?)* sp.
Lower Ream coal, Warrior Basin, Alabama; ser. 20285.

10 *Converrucosisporites* sp.
Cobb coal, Warrior Basin, Alabama; ser. 17776.

11 *Cristatisporites* sp.
Blue Creek coal, from well in Mississippi; ser. 17279.

12 *Punctata-sporites(?)* sp.
Fire Clay coal, Warrior Basin, Alabama; ser. 20452.
Trilete usually absent, exine finely granulose.

13 *Knoxisporites* sp.
Gillespie coal, Warrior Basin, Alabama; ser. 20714.

14 *Triquitrites* sp.
Croweburg coal (Broken Arrow), Des Moines series, Oklahoma; ser. 23741.

15 *Laevigato-sporites* sp.
Croweburg coal, Oklahoma; ser. 23864.

16 *Triquitrites* sp.
Croweburg coal, Oklahoma; ser. 23712.

17 *Pustulatisporites* sp.
Croweburg coal, Oklahoma; ser. 23777.

18 *Cristatisporites*. (*Punctati-sporites sulcatus* Wilson and Kosanke 1944.)
Croweburg coal, Oklahoma; ser. 17616.

19 *Endosporites* sp.
Croweburg coal, Oklahoma; ser. 7178.

20 *Schopfites colchesterensis* Kosanke 1950.
Croweburg coal, Oklahoma; ser. 23710.

21 *Endosporites* sp.
Croweburg coal, Oklahoma; ser. 7291A.

ABSTRACT: *The problematic microfossils* Globochaete alpina *Lombard and* Eothrix alpina *Lombard? are recorded from Portlandian limestones (Upper Jurassic) of Cuba. The new genera* Favreina *and* Lombardia *are introduced for other enigmatic forms from Upper Jurassic beds. Ten species of* Nannoconus, *which have proved useful in zoning Lower Cretaceous limestones in Cuba, are recognized. Their nomenclature and morphology are discussed in detail.*

Microfossils incertae sedis from the Upper Jurassic and Lower Cretaceous of Cuba

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INTRODUCTION

The systematically enigmatic organisms *Nannoconus* Kamptner, 1931, "organisme B" of Joukowsky and Favre (1913), *Globochaete alpina* Lombard, 1945, *Eothrix alpina* Lombard, 1945, and the "formes découpées" of Lombard (1938) are stratigraphically diagnostic microfossils, originally described from the Upper Jurassic and Lower Cretaceous of central and southern Europe. These organisms have also been encountered in the dense and lithologically rather uniform Portlandian and Neocomian limestones of Cuba, where they usually afford the only means of correlation and age determination. In a previous note on calpionellids (fossil tintinnids) found in Las Villas Province, Cuba (Bronnimann, 1954), reference was made to *Nannoconus colomi* (de Lapparent), a minute cone-shaped organism incertae sedis, which accompanies in great numbers the Neocomian calpionellids. The detailed morphologic analysis of the forms included under the name *N. colomi*, and the recognition of different species of *Nannoconus*, made it possible to introduce a finer zonation of the Lower Cretaceous limestones than was hitherto feasible. The other microfossils of problematic position mentioned above also serve as good markers for certain parts of the Upper Jurassic and Lower Cretaceous. Their biostratigraphic usefulness is further enhanced by their world-wide distribution in deposits of similar facies and age.

The following description of these interesting and stratigraphically significant Problematica is based mainly on material collected from outcrops in Las Villas Province, Cuba, by H. Wassall and P. Truitt, geologists of the Gulf Oil Corporation. Only a few samples come from localities situated in the provinces of Pinar del Río and Oriente, Cuba.

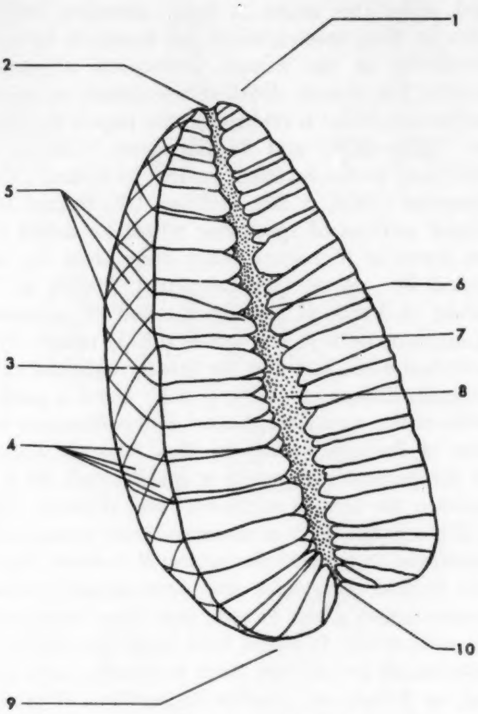
Holotypes and figured specimens will be deposited in the U. S. National Museum, Washington, D. C. The original samples remain in the collections of the Cuban Gulf Oil Company (CUGOC), Havana, Cuba.

The author is indebted to the Gulf Oil Corporation for the use of the facilities of the Geological Laboratory in Havana, and for permission to publish this paper; to G. Colom, Soller, Mallorca, H. Hiltermann, Hannover, and M. Lys, Rueil-Malmaison, for reprints of rare papers on *Nannoconus* Kamptner; to M. Reichel and L. Vonderschmitt, Basel, for material of the Biancone limestone from the Breggia near Balerna, southern Switzerland; to N. K. Brown, Jr., Havana, for reading and discussing the manuscript; and to H. E. Thalmann, Stanford University, California, for advice on taxonomic matters.

NANNOCONUS KAMPTNER, 1931

Representatives of *Nannoconus* occur in prodigious numbers in the dense Lower Cretaceous limestones. A single thin section contains numerous oriented and abundant oblique sections of the minute tests. As a rule, the number of oriented specimens in one thin section is more than adequate for biostratigraphic purposes and for morphologic investigations. Identification and closer study require high magnification and very fine sections, which are usually furnished by the thin marginal portions of ordinary thin sections. The preservation of the microfossils varies according to the lithology. The tests may be partially or completely destroyed by recrystallization, dolomitization and other diagenetic processes. They are best preserved in slightly silicified dense limestones with opaque or

micropaleontology, vol. 1, no. 1, pp. 28-51, pls. 1-2, text-figs. 1-10, chart I, january, 1955



TEXT-FIGURE 1

Schematic drawing of axial section of *Nannoconus steinmanni* Kamptner. 1, apex of test; 2, apical aperture; 3, surface of wedge; 4, wedges of a spiral; 5, wedges of a row perpendicular to the spiral; 6, pointed inner end of wedge; 7, wedge; 8, axial canal; 9, basal part of test; 10, basal aperture.

somewhat transparent matrix, where the fine dark outlines of the tests are distinct and the arrangement of the tiny individual structural elements of the walls can be clearly seen.

Morphology: The morphology of *Nannoconus* is imperfectly known. De Lapparent described the bottle-like test of *N. colomi* as composed of intercrossing calcite plates which are arranged obliquely to the axis of the test. The plates are believed to enclose minute pores. De Lapparent (1925*b*, p. 105) states: "L'organisme, de calcite hyaline, est fait de lames entrecroisées, obliques par rapport à son axe, et dont les intervalles constituent des pores." In 1931 (p. 223), he added: "La coquille, de calcite hyaline, est faite de lames entrecroisées qui isolent des pores et qui donnent en section mince l'impression d'une structure fibreuse."

Later in 1931, Kamptner described *Nannoconus* in more detail. He compared the shape of the test with a cone, which consists of numerous minute wedge-shaped parts arranged radially around and perpendicularly to the longitudinal axis of the test. The axis is represented by a thin canal, which opens at both ends of the test. The pointed portions of the wedges are directed toward the canal. No pores were observed between the closely packed wedges. Kamptner (1931, pp. 290, 291) described *Nannoconus* as follows:

> ". . . während die Längsschnitte der Zapfen das Bild zweizeiliger Fiederung bieten. Dies ist der Ausdruck einer eigentümlichen Feinstruktur der Zapfen; denn der Anblick rührt davon her, dass das Individuum aus einer ansehnlichen Zahl winziger, keilförmiger, rings um die Zapfenachse radiär angeordneter Teilchen aufgebaut ist. Diese Elemente stossen mit ihren spitzen Enden gegen innen zu an einen engeren oder breiteren, entlang der Achse verlaufenden Kanal . . . . dass die Bausteine annähernd senkrecht zur Achse orientiert sind und nur an den beiden Zapfenenden sich derart in ihren Radialebenen schief stellen, dass das mikroskopische Bild den Eindruck gibt, als wolle ihre Reihe von der einen Längsseite des Längsschnittes fächerförmig zur gegenüberliegenden umbiegen. Bei genauerer Betrachtung zeigt sich aber daselbst je eine terminale Lücke ausgespart, durch die der axiale Kanal an seinen beiden Enden nach aussen mündet."

The section perpendicular to the axis of the cones appears to be more or less hexagonal to subcircular.

In his second note on *Nannoconus*, Kamptner (1938, pp. 251, 252) confirmed his original description, especially the existence of two terminal apertures and the absence of pores between the individual wedges. He was not able, however, to disprove the existence of pores, which, if present, would be extremely small and difficult to see. Colom (1945, pp. 125, 129, text-fig. 2; 1948, p. 252, text-fig. 7) accepted de Lapparent's interpretation of the essential structural features, and his figures demonstrate that he believed, as de Lapparent did, that the test was bottle-shaped, with a rounded and closed basal portion and a single terminal aperture at the apex.

In the course of the present investigation, especially during the study of the globular and U-shaped *Nannoconus* species with relatively large axial cavity, it was found that the morphologic interpretations of de Lapparent and Kamptner must be modified. The internal structure of the test is the same, both in the cone-shaped forms with thin axial canal and in the bulbous, U-shaped and barrel-like to globular forms with relatively large cavity. The thin axial canal and the larger cavity of the stratigraphically younger species are regarded as homologues.

The longitudinal or axial section is the diagnostic one (text-fig. 1). It shows the following features arranged in order of their taxonomic importance:

(a) the outline and the dimensions of the test;
(b) the axial canal or the internal cavity;
(c) the thickness and the composition of the walls;
(d) the position and the diameter of the apertures.

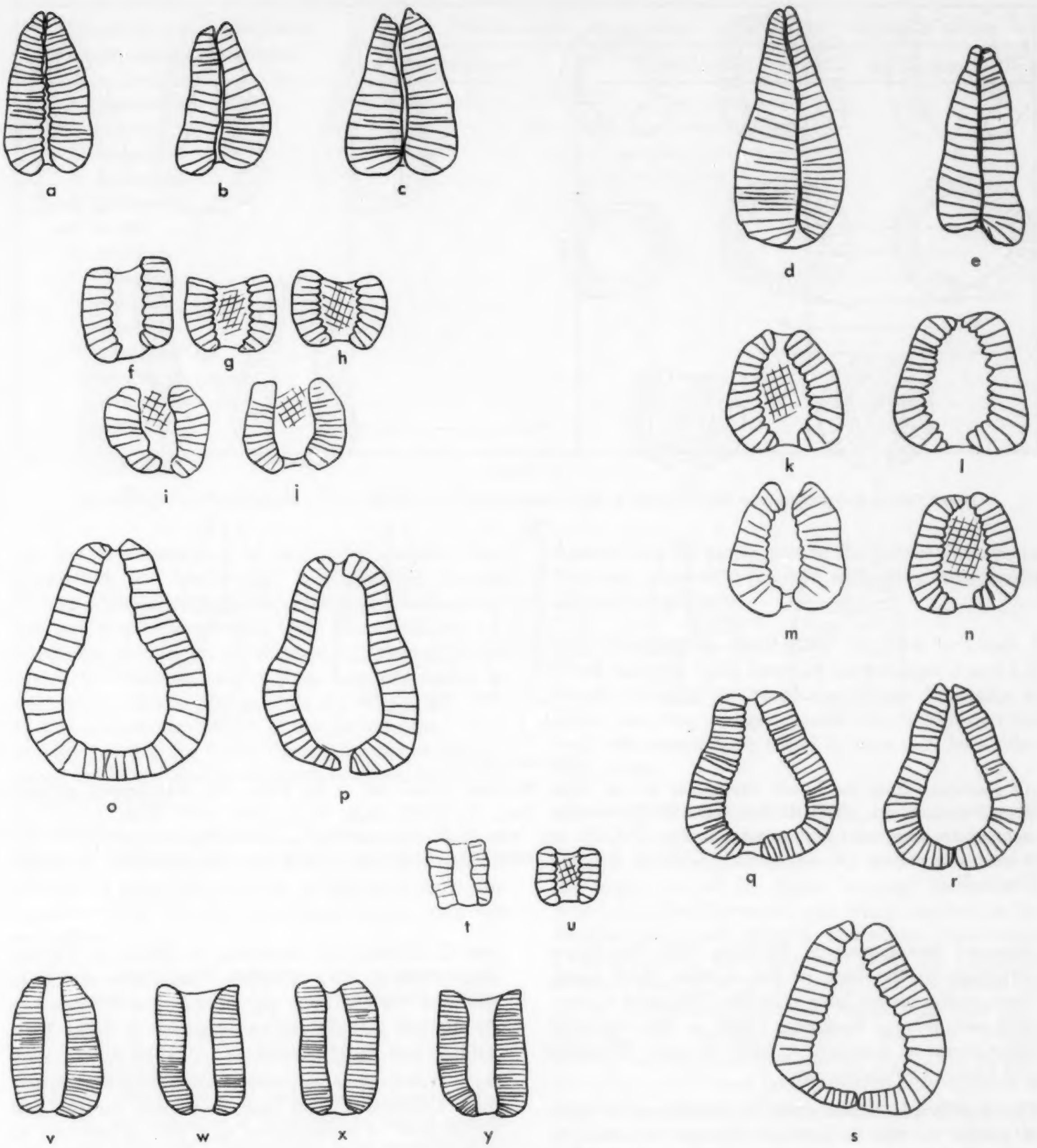
The wall consists of tiny wedges or plates oriented more or less perpendicularly to the surface of the test (pl. 1, fig. 2). Their pointed ends are directed toward the axial canal or cavity. A closer study of the distribution of the individual wedges in tangential sections of tests with large cavity indicates that they are arranged along a gradually mounting spiral or spirals (pl. 1, figs. 1, 3). Within the spiral or spirals, the wedges are aligned in rows perpendicular to the spiral and oblique to the longitudinal axis of the test. This arrangement creates the impression of an intercrossing pattern of plates, which stand oblique to the axis of the test, as described by de Lapparent. The wedges are somewhat pointed at the inner ends, and protrude slightly into the canal, thus producing a granulated inner surface (pl. 1, figs. 1, 3). The outer ends appear to be flush with the surface. The cross section of an individual wedge on the surface of the test is irregularly rhomboid. Because of the more or less perpendicular position of the wedges to the surface, the wall seems to be continuously developed and closed on the rounded basal side. This impression, however, is misleading. Kamptner's (1931, p. 291) statement can be confirmed, that the wall does not bend around continuously, but that the test has two terminal apertures opposite each other. Although magnifications up to 1700 times have been used, no pores could be seen between the individual wedges. The minute black points on the inner surface of large cavities (Kamptner, 1938) are here interpreted as the pointed inner ends of the wedges and not as pores. In these specimens all the wedges reach the cavity. In those with a thin axial canal, only some of the wedges apparently reach the center. This arrangement results in a rather irregular wall structure of fibrous appearance.

Sections perpendicular to the axis of the test are less diagnostic. They show the axial canal or internal cavity, the thickness, and the structure of the wall. The outline of the test, in such sections, is roughly circular, occasionally somewhat angular. Sections of this type may be similar in different species.

Nannoconus steinmanni Kamptner, 1931, was regarded as a junior synonym of *N. colomi* (de Lapparent) both by Kamptner (1938) and by Colom (1945). Heretofore, they were the only two specific names used under this genus. A fairly extensive literature exists on these species, which are known to be widely distributed in the Lower Cretaceous of southern Europe. For a more detailed orientation on previous studies the reader is referred to the papers by Kamptner (1931, 1938) and de Lapparent (1925*b*, 1926, 1931) and to the excellent review by Colom (1945). Kamptner (1938, p. 253, text-figs. 1-5) figured longitudinal sections of specimens which he called aberrant forms of *N. colomi*. They differ from the cone-shaped *N. colomi* (de Lapparent, 1925*b*, p. 105, text-fig. 1; 1926, pl. 10, fig. 1) and *N. steinmanni* (Kamptner, 1931, p. 291, text-figs. 2, 3) mainly by the short barrel-like test and the greatly enlarged cavity. Although Kamptner (1938, p. 253) noted a predominance of the forma *scyphoides* in the Biancone limestone of Possagno, southern Alps, Venetia, Italy, he did not propose subspecific or specific rank for it. He regarded the formae *scyphoides* and *depressa* (1938, p. 253, text-figs. 1-5) as abnormal tests connected by transitional stages with the typical *N. colomi*. (Kamptner's formae *scyphoides* and *depressa* are infrasubspecific names given to tests that were regarded by him as aberrant. It would have been desirable to use these names and elevate them to specific rank. However, as it was not possible to compare Kamptner's descriptions and figures with the original specimens, it was decided, in accordance with the ruling of the International Commission at the Paris meetings in 1948, to suppress them.) The analysis of numerous *Nannoconus* assemblages of known stratigraphic position in the Cuban material, however, showed that Kamptner's aberrant forms occur in different stratigraphic levels and, further, that they can be separated morphologically from *N. colomi*. Hence, they are here interpreted as new species of *Nannoconus*.

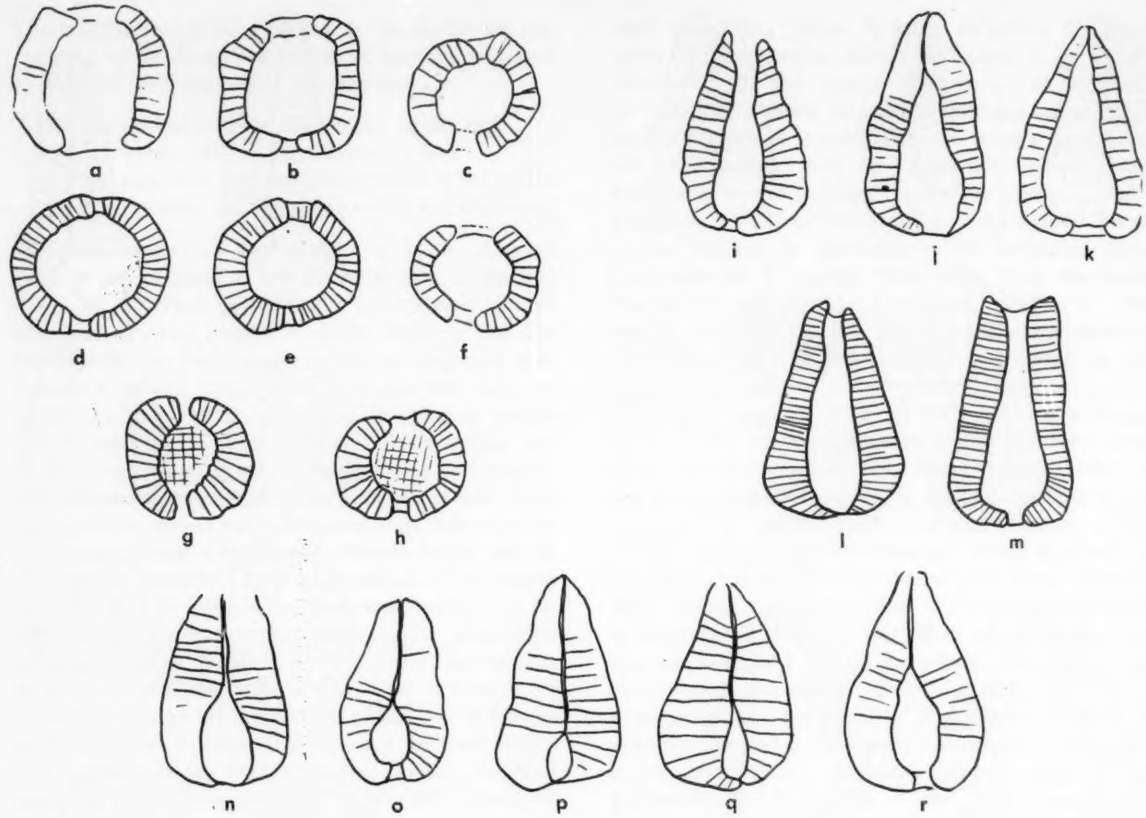
It is preferable, morphologically and taxonomically, to retain Kamptner's specific name *steinmanni* for the form illustrated by that author (1931, p. 291, text-fig. 2). *N. steinmanni* is morphologically different from the form designated here as *N. colomi* (de Lapparent).

Stratigraphic distribution: De Lapparent (1931, p. 223) recorded *N. colomi* in rock-forming quantities from the Valanginian to the lower Aptian, and rarely in the upper Aptian and lower Albian of Mallorca. It does not occur in beds with *Globotruncana*. The range of *Nannoconus* in Cuba agrees well with that given by de Lapparent from Mallorca. Colom (1945, p. 132) noted the intimate association of *Nannoconus* and calpionellids. However, he stated that *Calpionella alpina* and *Calpionella elliptica* appear in the Tithonian "false breccias" of Mallorca before the advent of *Nannoconus*. The same author (1948, p. 252)



TEXT-FIGURE 2

All specimens from the Lower Cretaceous of Las Villas Province, Cuba. All × ca. 2000. a-c, *Nannoconus steinmanni* Kamptner, CUGOC Ser. No. 21084(4); d-e, *Nannoconus bermúdezi* Bronnimann, n. sp., CUGOC Ser. Nos. 20942 (fig. 2d) and 21084(4) (fig. 2e); f-j, *Nannoconus truitti* Bronnimann, n. sp., CUGOC Ser. Nos. 21492(3) (figs. 2f-g) and 13714(2) (figs. 2i-j); k-n, *Nannoconus bucheri* Bronnimann, n. sp., CUGOC Ser. Nos. 13714(2) (fig. 2m) and 13725(1) (figs. 2k, 1, n); o-s, *Nannoconus wassalli* Bronnimann, n. sp., CUGOC Ser. No. 13725(1); t-u, *Nannoconus minutus* Bronnimann, n. sp., CUGOC Ser. Nos. 13714(2) (fig. 2t) and 21492(3) (fig. 2u); v-y, *Nannoconus elongatus* Bronnimann, n. sp., CUGOC Ser. No. 20277(1).



TEXT-FIGURE 3

All specimens from the Lower Cretaceous of Las Villas Province, Cuba. All × ca. 2000. a-h, *Nannoconus globulus* Bronnimann, n. sp., CUGOC Ser. Nos. 21927(4) (figs. 3a-c, f), 20761 (figs. 3d-e), and 14667 (figs. 3g-h); i-m, *Nannoconus kamptneri* Bronnimann, n. sp., CUGOC Ser. Nos. 21927(4), 21939(2), 21972(5), and 21566(1); n-r, *Nannoconus colomi* (de Lapparent), CUGOC Ser. Nos. 21877(5), 21927(4), 21939(2), and 21877(5). Holotype: Figure 3b.

observed *Nannoconus* in Mallorca from the upper Tithonian to the base of the Aptian. Here again, *Nannoconus* occurs later than the Tithonian *Calpionella* assemblages. Kamptner (1938, p. 256) regarded *Nannoconus* as restricted to beds of upper Tithonian and Lower Cretaceous age.

The stratigraphic distribution of *Nannoconus* in Cuba is similar to that in southern Europe. However, it seems to have appeared only after the typical upper Portlandian (Tithonian) *Calpionella* assemblages were superseded by the *Tintinnopsella carpathica—Tintinnopsella oblonga—Calpionella elliptica* assemblages of lowermost Cretaceous age. In Cuba, the dense radiolarian limestones and oölitic-pseudoölitic limestones with ammonites immediately underlying the lithologically slightly different limestones with *C. alpina* and *C. elliptica* are, according to Imlay (in Bronnimann, 1954, p. 263), of middle Portlandian age. As in the Alps (Weiss, 1949, pp. 23, 24), the *C. alpina — C. elliptica* assemblages are regarded as upper Portlandian, and the *C. carpathica—T. oblonga—C. elliptica—Nannoconus steinmanni* assemblages as lowermost Cretaceous. This age assignment for the first appearance of *Nannoconus* in Cuba appears to be fairly well established by the underlying Tithonian ammonite and *Calpionella* assemblages and by the associated Neocomian Calpionellas. But in order to confirm this age, additional evidence is needed, preferably discoveries of ammonites. The upper limit of *Nannoconus* in Cuba is represented by a rather wide age interval. It is characterized by the occurrence of *Orbitolina* sp. (ex gr. *O. concava—O. texana*), and by

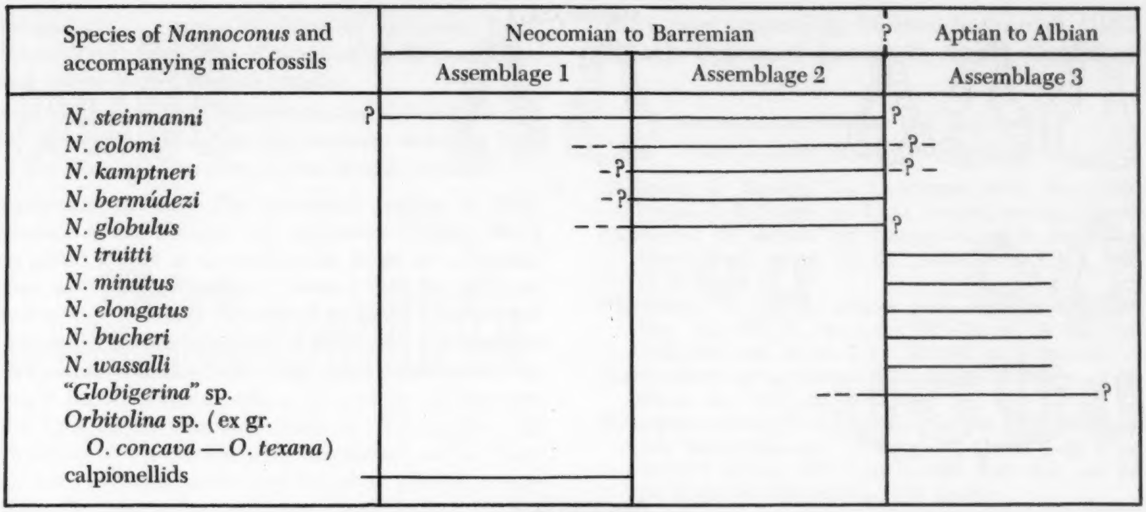


CHART 1

Stratigraphic distribution of the species of *Nannoconus* and of some of the accompanying microfossils

the first representatives of small, thick-walled, five-chambered, low trochospiral "Globigerinas." Except for rare, obviously redeposited specimens, *Nannoconus* has not been encountered with *Globotruncana* s.l. *Orbitolina* sp. (ex. gr. *O. concava—O. texana*) is reported in Venezuela and in Texas from the Aptian to the middle Albian (Maync, 1954, fig. 30, pp. 276, 277, in Rod and Maync, 1954). If this distribution is also accepted as true for Cuba, the total range of *Nannoconus* can be given as lowermost Cretaceous to Aptian — middle Albian.

The stratigraphic distribution of the species of *Nannoconus* is compiled in Chart 1. It is the result of an analysis of many thin sections of known stratigraphic position. Three typical assemblages occur, from top to bottom:

(3) *N. truitti — N. minutus — N. elongatus — N. bucheri — N. wassalli*, associated with *Orbitolina* sp. (ex gr. *O. concava — O. texana*) and with the first "Globigerinas," of a yet undescribed type.

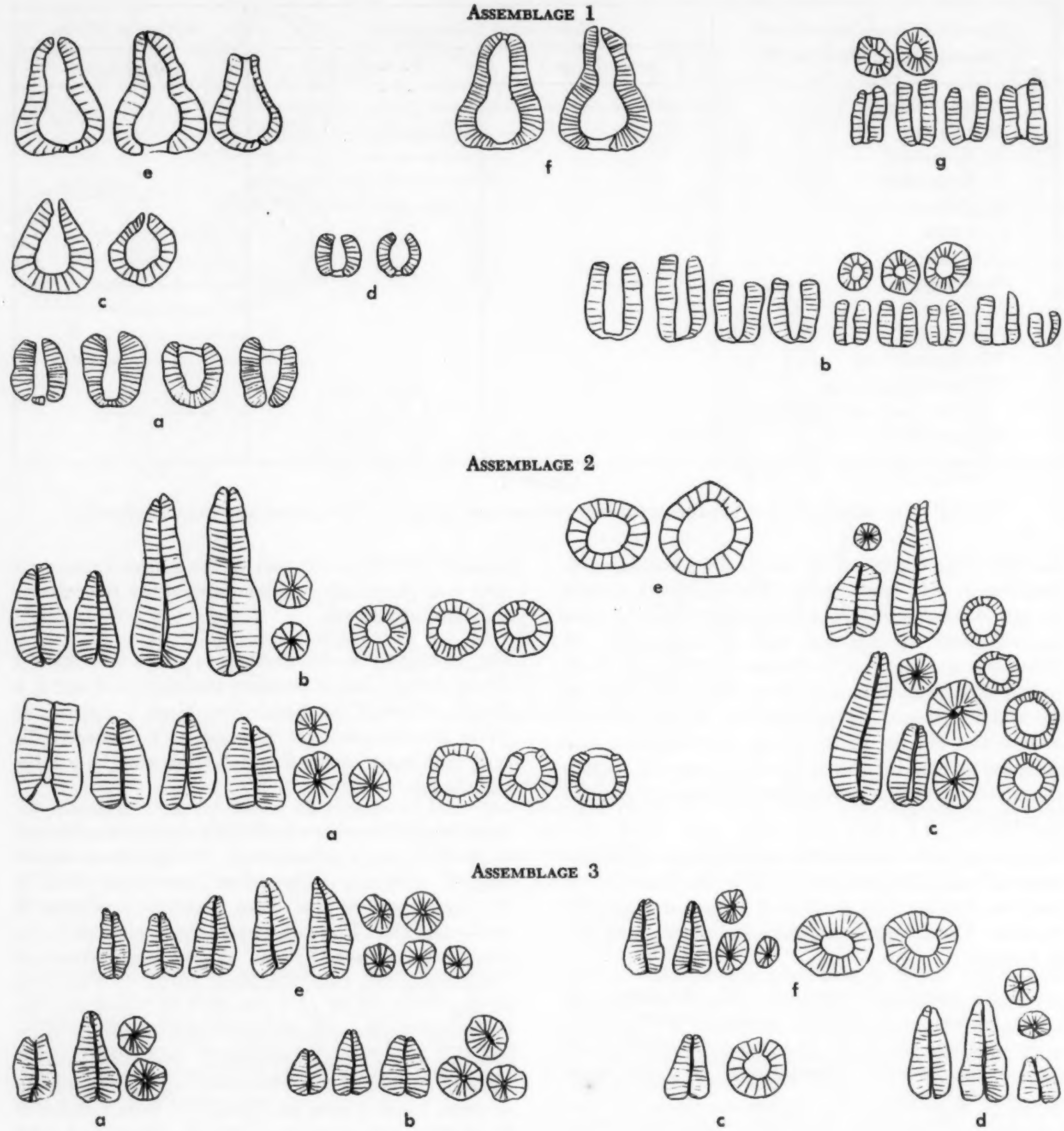
(2) *N. steinmanni — N. colomi — N. kamptneri — N. bermúdezi — N. globulus* (a single section contains rare "Globigerinas" as in assemblage 3).

(1) *N. steinmanni — N.* aff. *globulus — N. colomi*, associated with calpionellids.

The three faunas are stratigraphically arranged in text-fig. 4. However, only the more common species are illustrated. The three *Nannoconus* faunas are easily recognizable, and, together with the calpionellids, enable the stratigrapher to introduce a far more detailed zonation for the major part of the Lower Cretaceous than was previously possible with other microfossils and rare megafossils.

The stratigraphic distribution as given in Chart 1 shows that the break between assemblages 3 and 2 is abrupt, whereas the basal assemblage 1 appears to grade into the younger assemblage 2. Between the beds with assemblages 2 and 3, there may be a lithologic break.

Assemblage 2 has been tentatively assigned in Chart 1 to the Barremian. Subsequently, the species of assemblage 2, excepting *N. kamptneri*, have been found in the upper part of the dense Biancone limestone of well-established Barremian age, which outcrops in the Breggia gorge, near Balerna, in southern Switzerland (Vonderschmitt, 1941; Gandolfi, 1942). In Gandolfi's section (1942, p. 13, pl. 1), strata 1 to 5 represent the top of the Biancone limestone, which is directly overlain by the "Scaglia variegata" and the "Scaglia bianca," of Aptian to Cenomanian age. Thin sections of strata 1 and 4 have been prepared from samples of Gandolfi's original material, kindly donated by M. Reichel. A thin section from stratum 1 contains the following fauna: *N. steinmanni* (abundant); *N. colomi* (rare); *N. globulus* (abundant); *N. bermúdezi* (rare); *"Globigerina"* sp., five-chambered, thick-walled, identical with those observed in the Cuban material (rare); fragments of ostracode shells (common); and yellow-brown organic remains. A thin section from stratum 4 contains the following fauna: *N. steinmanni* (abundant); *N. colomi* (rare); *N. globulus* (abundant); *N.*



TEXT-FIGURE 4

Nannoconus assemblages arranged in stratigraphic order. All figures × ca. 1000. 1, *Nannoconus* assemblages associated with *"Globigerina"* sp. and with *Orbitolina* sp. (ex gr. *O. concava — O. texana*): a, d, CUGOC Ser. Nos. 20224(1), (2), *N. truitti;* b, CUGOC Ser. No. 20211, *N. elongatus, N.* cf. *truitti, N. minutus;* c, e, f, CUGOC Ser. Nos. 20211, 20245(1), *N. wassalli;* g, CUGOC Ser. No. 20270, *N. elongatus.* 2, *Nannoconus* assemblages associated with Radiolaria, without calpionellids and *"Globigerina"* sp.: a-d, CUGOC Ser. Nos. 20939(3), 20940(1), 20942(1) and 20944(1), *N. steinmanni, N. bermúdezi, N. globulus;* e, CUGOC Ser. No. 14909, *N. globulus.* 3, *Nannoconus* assemblages associated with calpionellids: a, b, d, e, CUGOC Ser. Nos. 20929(1), 14874A(1), 20031(1), and 20931, *N. steinmanni;* c, f, CUGOC Ser. Nos. 20927 and 21429(5), *N. steinmanni, N.* aff. *globulus.*

bermúdezi (very rare); "*Globigerina*" sp. (rare); Radiolaria? (rare); fragments of ostracode shells (common); and yellow-brown organic remains.

Assemblage 1 with *N. steinmanni* and *Calpionella* spp. has been encountered in thin sections from the base of the Biancone limestone of the Breggia section.

Systematic position: The systematic position of *Nannoconus* is still obscure. De Lapparent (1925*b*, 1931) regarded it first as an embryonic stage of a *Lagena*, then as a *Lagena* proper. Colom (1945, p. 125) reported that Cadisch considered it to be a unicellular chlorophyllaceous alga which produced a calcareous test, and later Cadisch even suggested that *Nannoconus* might be of inorganic origin, formed by calcite crystals in a highly saturated medium. The similar wall structure of *Fibrosphaera* de Lapparent and of *Nannoconus* indicates, according to Colom (1945), a morphologic relationship between these forms. He assigned them to the same, but systematically still enigmatic group of microscopic organisms.

The spiral structure of the test of *Nannoconus* is reminiscent of the multi-spiralled structure of the oögonia of certain Charophyta. Peck (1941, pl. 42, fig. 30) figured an oögonium of *Clavator harrisi* Peck which, below a thin cuticle, shows a distinct spiral arrangement of small intercellular units. Oögonia with intercellular structure are also developed in the Tertiary genus *Kosmogyra*. The Devonian to Carboniferous genus *Sycidium* develops oögonia with a peculiar cellular structure, which is probably of spiral nature (Peck, 1934). The possible relationship between tests of *Nannoconus* and oögonia of algae should be investigated further.

Systematic descriptions:

Genus **Nannoconus** Kamptner, 1931

Genotype: Lagena colomi de Lapparent, 1931.

Definition: Test minute, length from about 5μ to about 50μ, on the average 15μ to 20μ; width from about 5μ to about 15μ. Outline in longitudinal section is conical or spherical, barrel- or pear-shaped, or more or less cylindrical, U-shaped. Wall a single layer of tiny wedges of calcite, about 1μ in thickness, oriented perpendicularly to the surface, with their pointed ends toward the axial canal or the homologous large central cavity. Wedges arranged in a gradually mounting spiral or spirals, and in longitudinal rows perpendicular to the spiral and oblique to the axis of the test. Two terminal apertures, opposite each other; possibly more than two in certain barrel-shaped forms.

Occurrence: Mediterranean area; Rumania; Cuba; probably also Mexico, where calpionellids have recently been reported by Maldonado-Koerdell (1953, p. 114). Uppermost Jurassic(?), Lower Cretaceous.

Nannoconus colomi (de Lapparent)
Plate 2, figures 9, 17; Text-figure 3n-r

"Embryons de *Lagena*," DE LAPPARENT, 1925, Soc. Géol. France, C. R. Somm., no. 7, pp. 104-106, text-fig. 1 (part).

?"Embryons de *Lagena*," DE LAPPARENT, 1926, Soc. Géol. France, Bull., ser. 4, vol. 25 (1925), fasc. 4-5, p. 353, pl. 10, fig. 1.

?"Embriones de *Lagena*," COLOM, 1928, Soc. Española Hist. Nat., Bol., vol. 28, no. 7, pp. 393-404, pl. 10, figs. 1-4; 1931, ibid., vol. 31, no. 7, pp. 529-545, pl. 6, figs. 4-5.

Lagena colomi DE LAPPARENT, 1931, Soc. Géol. France, C. R. Somm., no. 14-15, pp. 222-223.

Nannoconus colomi (de Lapparent).—COLOM, 1945, Barcelona, Inst. Geol., Publ., vol. 7 ("Miscelanea Almera"), pt. 1, pp. 123-132, text-fig. 2(?) (part); 1948, Jour. Pal., vol. 22, no. 2, pp. 233-263, text-fig. 7(?) (part).

Lectotype: De Lapparent (1925*b*, p. 105, text-fig. 1; 1926, pl. 10, fig. 1) illustrated *Lagena colomi* in fourteen pen drawings of longitudinal and vertical sections of specimens originating from the Berriasian limestones of Gigondas, Provence, France, and from the Barremian limestones of Mallorca, Baleares, and also by a photograph (×260) of a thin section of a limestone with Radiolaria and *Nannoconus* from Mallorca. The composite drawing evidently represents two different types of *Nannoconus*, one with a narrow longitudinal canal, and one with a small bulbous cavity at the basal end of the test. From the cavity, a thin axial canal extends to the apical aperture as in the forms without basal cavity. Besides the longitudinal sections, there are also four sections perpendicular to the axis, showing the characteristic ring with radially structured wall. The diameter of the cavity depends upon the position of the perpendicular section. The sections with large cavities probably belong to the forms with bulbous axial canal near the basal portion of the test. Of these two distinct types, the one with the basal bulbous cavity is here named *N. colomi*. The specimen on the extreme right side of de Lapparent's text-fig. 1 on p. 105 (1925*b*) is designated as lectotype of *Nannoconus colomi* (de Lapparent). It is believed that the lectotype comes from the Barremian limestone of Mallorca. Its origin will have to be established by comparing the original material of de Lapparent with the figured specimens. Limestones of Lower Neocomian age, as a rule, contain predominantly the form with a straight and thin axial canal, later described as *N. steinmanni*.

Description: The test is cone-shaped. The length is from 10μ to 12μ. The base of the cone is rounded to flat. The basal bulbous cavity of about 2μ to 5μ maxi-

mum diameter extends into the thin axial canal. The apical aperture is a minute opening; the basal aperture, on the other hand, is much larger and the diameter is close to that of the basal cavity. The diameter of the wall is about 2μ to 5μ. It consists of a single layer of wedges about 1μ in thickness, which are more or less perpendicular to the surface and arranged in a gradually mounting spiral. They form longitudinal rows oblique to the axis and perpendicular to the spiral. This gives the impression of an intercrossing pattern, described by de Lapparent (1931, p. 223) as "lames entrecroisées." Although high magnifications have been used, no pores have been observed between the individual wedges.

Comparisons: The elongate, conical test is common to *N. colomi, N. steinmanni, N. bermúdezi* n. sp., and *N. kamptneri* n. sp. *N. steinmanni* has a distinctly pointed apical end and is penetrated by a thin axial canal. *N. kamptneri* n. sp., although cone-shaped, has a much broader apical portion, a wide axial canal, and a large apical opening. *N. bermúdezi* n. sp. is close to *N. steinmanni* in shape and axial canal, but differs from that species in its larger dimensions. *N. colomi* differs in the basal bulbous cavity from *N. steinmanni* and *N. bermúdezi* n. sp., both of which display a thin axial canal. The four species apparently form a closely related group.

Remarks: In Cuba, *N. colomi, N. bermúdezi* n. sp. and *N. kamptneri* n. sp. occur later than *N. steinmanni.*

Nannoconus steinmanni Kamptner
Plate 1, figure 16; Plate 2, figures 10, 15
Text-figure 2a-c

"Embryons de *Lagena,*" DE LAPPARENT, 1925, Soc. Géol. France, C. R. Somm., no. 7, pp. 104-106, text-fig. 1 (part).
Nannoconus steinmanni KAMPTNER, 1931, Pal. Zeitschr., vol. 13, pp. 288-297, text-figs. 2, 3.
?*Nannoconus colomi* (de Lapparent).—COLOM, 1945, Barcelona, Inst. Geol., Publ., vol. 7 ("Miscelanea Almera"), pt. 1, pp. 123-132, text-fig. 2 (part); 1948, Jour. Pal., vol. 22, no. 2, pp. 233-263, text-fig. 7 (part).

Lectotype: The longitudinal section illustrated by Kamptner's photograph (1931, p. 291, text-fig. 2) is herewith designated as the lectotype of *N. steinmanni.* The specimen is from the Biancone limestone of Monte Pavione, southern Alps, Italy, which is, according to Kamptner, of upper Tithonian (Portlandian) age.

Description: The length of the cone-shaped test is from about 10μ to about 20μ, and the maximum diameter from 5μ to 10μ. The base of the cone is flat, occasionally rounded. The test is pierced by a thin axial canal which opens into two terminal apertures, one at the apical and one at the basal end. The walls decrease in width from the base, where they are 2.5μ to 5μ thick, to the pointed apex. They consist of a single layer of wedges about 1μ thick, arranged as described in *N. colomi.* There are apparently no pores between wedges.

Comparisons: N. steinmanni differs from *N. colomi* in the absence of the bulbous basal cavity, and from *N. bermúdezi* n. sp. in the much smaller size. The conical *N. kamptneri* n. sp. differs from *N. steinmanni* in having a much wider axial canal.

Remarks: Random measurements of length and maximum diameter of *N. steinmanni* in assemblages of different stratigraphic position show the following values in microns:

(a) CUGOC Ser. No. 14874A, associated with *Calpionella elliptica* (abundant), *Tintinnopsella carpathica* (very rare), and *Tintinnopsella oblonga* (common).
Length: 7.5 to 12.5 (average 10.5)
Width: 6.25 to 7.5 (average 6.6)

(b) CUGOC Ser. No. 21182(1), associated with *Calpionella elliptica* (common), *Tintinnopsella oblonga* (common), *Amphorellina lanceolata* (one specimen), calpionellid sp. (rare).
Length: 11.5 to 12.5 (average 12.0)
Width: 6.25 to 7.5 (average 7.1)

(c) CUGOC Ser. No. 21031(1), associated with *Tintinnopsella carpathica* (abundant), *Tintinnopsella oblonga* (common), *Calpionellites darderi* (rare).
Length: 11.5 to 17.5 (average 13.5)
Width: 6.75 to 7.5 (average 7.2)

(d) CUGOC Ser. No. 20942(1), without calpionellids, associated with *N. bermúdezi* (rare), *N. globulus* (abundant), Radiolaria (abundant).
Length: 11.25 to 17.5 (average 15.0)
Width: 7.5 to 10.0 (average 9.0)

The average values of length and maximum width of *N. steinmanni* increase from 10.5μ and 6.6μ, respectively, in old Lower Cretaceous limestone with Calpionellas, to 15μ and 9μ, respectively, in younger Lower Cretaceous limestones without Calpionellas and without "Globigerinas." *N. steinmanni* is the dominant *Nannoconus* species of the Neocomian limestones.

In Cuba, *N. steinmanni* is the oldest known species of *Nannoconus,* but occurs also after the disappearance of *Calpionella.* It is associated with *N. colomi, N. kamptneri* n. sp., *N. bermúdezi* n. sp. and *N. globulus* n. sp.

Nannoconus bermúdezi, new species
Plate 2, figures 1, 24; Text-figure 2d-e

Nannoconus colomi (de Lapparent).—Colom, 1945, Barcelona, Inst. Geol., Publ., vol. 7 ("Miscelanea Almera"), pt. 1, p. 129, text-fig. 2 (specimen at extreme right of text-figure); 1948, Jour. Pal., vol. 22, no. 2, p. 252, text-fig. 7 (specimen at extreme right of text-figure).

Holotype: N. bermúdezi Bronnimann, n. sp., pl. 2, fig. 24, from CUGOC Ser. No. 20942, Las Villas Province, Cuba; Lower Cretaceous.

Description: The features of the cone-shaped test are similar to those of *N. steinmanni.* The length ranges from 20μ to about 28μ, and the maximum diameter is about 10μ.

Comparisons: N. bermúdezi n. sp. differs from all other cone-shaped forms by its greater dimensions, which are about one and one-half to two times larger than those of the average *N. steinmanni,* to which it is structurally closely related.

Remarks: As a rule, *N. bermúdezi* n. sp. occurs rather rarely. In the Cuban material it has been noted only in the post-calpionellid zones, where it is associated with *N. steinmanni, N. colomi, N. globulus* n. sp., and *N. kamptneri* n. sp. It is regarded as a good marker in the *Nannoconus*-calpionellid zonation of the Neocomian.

Colom (1945, text-fig. 2) figured a test about 50μ in length which is here tentatively assigned to *N. bermúdezi* n. sp., although no such extreme specimens have been measured in the Cuban material.

The species is named for P. J. Bermúdez, in recognition of his contributions to the micropaleontology of the Caribbean area.

Nannoconus kamptneri, new species
Plate 2, figures 14, 16, 20, 21; Text-figure 2i-m

"Embriones de *Lagena*," Colom, 1928, Soc. Española Hist. Nat., Bol., vol. 28, no. 7, pp. 393-404, text-fig. 1.

Holotype: N. kamptneri Bronnimann, n. sp., pl. 2, fig. 16, from CUGOC Ser. No. 21566(1), Las Villas Province, Cuba; Lower Cretaceous.

Description: The length of the cone-shaped test ranges from 15μ to 22μ, and the maximum diameter from 9μ to 12μ. The cavity with a diameter of 4μ to 5μ near the rounded basis of the test leads into a wide canal which opens into a terminal aperture of 2μ to 3μ. The wall and its structural elements are like that of *N. colomi.*

Comparisons: N. kamptneri differs from all other cone-shaped species by its basal cavity, wide axial canal and large terminal aperture. It is structurally related to *N. colomi,* from which it may have developed by enlargement of the axial canal and basal bulbous cavity. Sections perpendicular to the axis of *N. kamptneri, N. colomi* and *N. globulus* cannot always be distinguished.

Remarks: Although Colom's (1928, p. 394, text-fig. 1) pen drawings of "embriones de *Lagena*" from the Lower Cretaceous of Mallorca are rather schematic, it appears that his specimens are *N. kamptneri* n. sp. This species occurs in post-calpionellid *Nannoconus* assemblages, where it is associated with *N. colomi, N. steinmanni, N. bermúdezi* n. sp., and *N. globulus* n. sp.

The species is named for E. Kamptner, who first recognized morphologic differences in tests of *Nannoconus.*

Nannoconus globulus, new species
Plate 2, figures 13, 18, 23; Text-figure 3a-h

Holotype: N. globulus Bronnimann, n. sp., text-fig. 3b, from CUGOC Ser. No. 21927(4), Las Villas Province, Cuba; Lower Cretaceous.

Description: The test is low barrel-shaped, occasionally more or less globular. Its maximum diameter is from 8.5μ to 14μ, and the thickness of the wall ranges from 1μ to 2.5μ. The test has two terminal apertures about 2μ in diameter. The single-layered wall consists of tiny wedges about 1μ in thickness, which are arranged as in *N. colomi.* The spiral disposition of the wall elements can be clearly recognized in sections tangential to the inner surface. The more or less ring-like sections perpendicular to the axis display a subcircular cavity, large in relation to the thickness of the walls, and, as a rule, one or both of the terminal apertures. No pores were observed between the wedges.

Comparisons: N. globulus differs from all other species of *Nannoconus* in its low barrel-shaped to more or less spherical test with large cavity. Its ring-like sections perpendicular to the axis can easily be recognized.

Smaller representatives of *N. globulus* n. sp. have been observed in early *Nannoconus* assemblages; these early forms (text-fig. 3g, h) have a distinctly smaller cavity and a thicker wall than the typical *N. globulus* n. sp., and may possibly represent a separate taxon.

Remarks: At first, *N. globulus* was believed to be a representative of *Fibrosphaera* de Lapparent, 1925, an enigmatic globular microfossil originally reported from the Danian *Globigerina* limestone of Fontarabie and Henday, western Pyrenees (de Lapparent, 1925*a*, p. 617, fig. 1). Colom (1935, p. 11, fig. 4) described spherical cross-sections of similar globular micro-

organisms occurring in the upper Lias of Mallorca as *F. minutissima* Colom and *F. stephanoidea* Colom. Well-preserved representatives of *Fibrosphaera*, resembling *F. minutissima* Colom, have been observed associated with *N. steinmanni* in Neocomian limestone from Las Villas Province. The sections are like thick-walled rings with a diameter ranging from 30μ to 50μ; the central cavity is exactly circular in cross-section and well defined; it measures about 15μ to 24μ. The periphery of the ring, on the other hand, is somewhat irregular due to protruding wall elements. The aspect of the wall in cross-section is distinctly fibrous. Apertures appear to be absent. De Lapparent's *Fibrosphaera* is not larger than 30μ, and the single-layered wall is composed of minute wedge-shaped elements, reminiscent of the wall structure of *Nannoconus*. The affinity is so distinct that Colom (1945, p. 128) regarded *Nannoconus* and *Fibrosphaera* as closely related genera. However, the absence of apertures in all the described representatives of *Fibrosphaera* differentiate the two groups.

N. globulus n. sp. is associated with *N. colomi*, *N. steinmanni*, *N. kamptneri* n. sp. and *N. bermúdezi* n. sp.

Nannoconus truitti, new species
Plate 2, figures 2-5, 7; Text-figure 2f-j

Holotype: N. truitti Bronnimann, n. sp., pl. 2, fig. 2, from CUGOC Ser. No. 13152(2), Las Villas Province, Cuba; Lower Cretaceous (Aptian to Albian).

Description: The U-shaped *N. truitti* is almost square in axial section. It has a maximum diameter from 7.5μ to 10μ. The basal portion is slightly rounded and the top is flat. The walls are 2.5μ to 3μ thick, parallel to each other, and enclose an elongate cavity, the diameter of which is equal to the thickness of the wall. The wall is composed of wedges about 1μ in thickness, which are pointed toward the cavity. They are arranged spirally as in *N. colomi*. There are two terminal apertures; the basal one is, as a rule, slightly smaller than the apical one, which is large and of the same width as the cavity.

Comparisons: N. truitti n. sp. differs from the related smaller *N. minimus* n. sp. and the longer *N. elongatus* n. sp. in its size and in the proportions of the U-shaped test, and from *N. wassalli* n. sp. and *N. bucheri* n. sp. in the U-shaped test. All of these species appear after the group of *N. colomi* — *N. globulus* becomes extinct.

Remarks: N. truitti n. sp. is the most abundant and characteristic *Nannoconus* species of the group of forms characterized by U- and pear-shaped tests and relatively wide cavities. It is associated with the first "Globigerinas."

The specimen described by Kamptner (1938, p. 253, text-fig. 5) as forma *scyphoides* may be *N. truitti* n. sp. or *N. globulus* n. sp. The correct assignment of Kamptner's formae must await the revision of his original material.

The species is named for P. Truitt, geologist of the Gulf Oil Corporation.

Nannoconus minutus, new species
Plate 2, figures 4, 6, 8, 12; Text-figure 2t-u

Holotype: N. minutus Bronnimann, n. sp., pl. 2, fig. 8, from CUGOC Ser. No. 21492(3), Las Villas Province, Cuba; Lower Cretaceous (Aptian to Albian).

Description: N. minutus n. sp., with a maximum diameter of 5μ to 6.5μ, is the smallest *Nannoconus* species found to date. Its test has the form of a U-shaped square. In axial section it is like *N. truitti* n. sp., practically flat at the base and at the top. The parallel walls and the enclosed cavity are each about 2μ in diameter. The two terminal apertures are of equal width. The inner structure of the walls is identical with that of *N. colomi*, with the exception that the wall elements run practically horizontal.

Comparisons: N. minutus n. sp. differs from *N. truitti* n. sp. not only in the smaller size but also in the more angular basal portion of the test. Specimens intermediate in dimensions between *N. minutus* n. sp. and *N. truitti* n. sp. may occur, but have not been noted. The two species are regarded as well-defined taxonomic units.

Remarks: This species occurs with *N. truitti* n. sp., *N. elongatus* n. sp., and *N. bucheri* n. sp., after the extinction of the *N. colomi* — *N. globulus* group. *N. minutus* n. sp. is a common form, but never as abundant as its larger relative *N. truitti* n. sp.

Nannoconus elongatus, new species
Plate 1, figures 10-14; Text-figure 2v-y

Holotype: N. elongatus Bronnimann, n. sp., pl. 1, fig. 10, from CUGOC Ser. No. 21492(3), Las Villas Province, Cuba; Lower Cretaceous (Aptian to Albian).

Description: The test is U-shaped in axial section, longer than wide; the length is from 10μ to 12.5μ, the width from 6.5μ to 9μ. The diameter of the cavity, 1.5μ to 2.5μ, is, as a rule, slightly smaller than that of the walls, which run parallel to each other. The two terminal apertures are equal in width to the cavity. In axial section, the top rim of the test shows a slight inclination toward the aperture (text-fig. 2w, y). The wall is constructed like that of *N. colomi*.

Comparisons: *N. elongatus* n. sp. differs from the other U-shaped species in its longer test. The U-shaped *N. truitti* n. sp., *N. minutus* n. sp., and *N. elongatus* n. sp. are closely related. They are, however, sufficiently well differentiated to be recognized as distinct species.

Remarks: The three species are associated. *N. truitti* n. sp. is the dominant form.

Nannoconus bucheri, new species
Plate 1, figures 1-3, 5-7; Text-figure 2k-n

Holotype: *N. bucheri* Bronnimann, n. sp., pl. 1, fig. 2, from CUGOC Ser. No. 21492(3), Las Villas Province, Cuba; Lower Cretaceous (Aptian to Albian).

Description: In axial section, the test is subovoid, with broad and flat basal portion. The length ranges from 11μ to 14μ and the maximum diameter from 10μ to 11μ. The walls are from 3μ to 4μ thick; they enclose a large ovoid cavity which opens into two terminal apertures. The top portion of the test is slightly rounded to flat. The structure of the single-layered wall is like that of *N. colomi.*

Comparisons: *N. bucheri* n. sp. differs from the U-shaped species by its ovoid axial section. It appears to be related to the pear-shaped *N. wassalli* n. sp. Tangential sections of *N. wassalli* n. sp. could be mistaken for axial sections of *N. bucheri* n. sp.

Remarks: *N. bucheri* n. sp. occurs with *N. truitti* n. sp., *N. minutus* n. sp., *N. elongatus* n. sp., and occasionally with *N. wassalli* n. sp. This stratigraphically younger group is clearly differentiated morphologically from the *N. steinmanni* — *N. colomi* — *N. kamptneri* — *N. bermúdezi* — *N. globulus* group.

Nannoconus wassalli, new species
Plate 1, figures 4, 8, 9, 15, 17, 21
Plate 2, figure 22; Text-figure 2o-s

Holotype: *N. wassalli* Bronnimann, n. sp., pl. 1, fig. 8, from CUGOC Ser. No. 20245(1), Las Villas Province, Cuba; Lower Cretaceous (Aptian to Albian).

Description: The pear-shaped test is relatively large for the genus; its length is from 14μ to 20μ and the maximum diameter from 11μ to 14μ. The walls are about 3μ thick and enclose a large, pear-shaped, sometimes ovoid cavity, which opens into two relatively small terminal apertures, 2.5μ to 3μ in diameter. The structure of the wall is like that of *N. colomi.*

Comparisons: *N. wassalli* n. sp. is the largest and, because of its pear-shaped test, the most conspicuous of the group of *Nannoconus* species associated with "Globigerinas."

Remarks: This species occurs with *N. truitti* n. sp., but has not been found in all assemblages. Perhaps it is of stratigraphic significance. The species is named for H. Wassall, geologist of the Gulf Oil Corporation.

FAVREINA, NEW GENUS

In thin sections of limestones from the upper part of the marine Portlandian (=Purbeckian) at Mt. Salève, near Geneva, Switzerland, Joukowsky and Favre (1913, pl. 14, fig. 1) observed dark, subrectangular and rounded organic fragments showing a rather regular pattern of long, thin canals and of pores. The fragments with pores are obviously the transverse sections of those with the long canals. The systematic position of the peculiar microfossil which they called "organisme B" was unknown to Joukowsky and Favre. Later, Favre and Richard (1927, pp. 11, 23, 36, text-fig. 12) found "organisme B" in the upper Portlandian oölitic and pseudoölitic limestones of the Cluse de Balme, in the southern Jura, and it was also encountered by Tutein Nolthenius (1921, p. 16, figs. f-h and k-l) in the Portlandian limestone of the Vallée de Joux, in the Swiss Jura (fide Favre and Richard, 1927, p. 36). Pfender (1927, p. 92, pl. 5, fig. 6) reported "organisme B," associated with *Clypeina jurassica* Favre, from Jurassic-Cretaceous white limestones normally overlying Upper Jurassic dolomites at Nans, Var, Basse-Provence, France. Thus "organisme B", for which herein the name *Favreina* n. gen. is proposed, appeared to have all the characteristics of a good index fossil. It is easily recognizable, has a wide geographic distribution, and is restricted to the marine beds of the upper Portlandian. Recently, however, Cuvillier has supplied additional information on the range of *Favreina* which seems to reduce its stratigraphic usefulness. He illustrated (1951, pl. 4, fig. 2) typical representatives of *Favreina* in a fine pseudoölitic limestone, assigned to an Infra-Lias age, found at a depth of 1844 meters in Saint Médard (Gers) well no. 1. Cuvillier reported it also from beds referred to the Infra-Lias "breccias" in Audignon well no. 1, at a depth of 2130-2170 meters, and elsewhere along the northern Pyrenées. Of the latter occurrences, no localities nor ages are mentioned. In the same paper (Cuvillier, 1951, pl. 17, fig. 1), a different species of *Favreina* is also figured, from a coarse pseudoölitic limestone referred to the middle to upper Aptian, found at a depth of 2590 meters in Garlin (B.-P.) well no. 2. This species of *Favreina* has also been

encountered in Garlin (B.-P.) well no. 3, at Roquefort, and elsewhere. No specific evidence is offered by Cuvillier in support of his age assignments.

The specimens from the Infra-Lias and Aptian are related in structure, but different in shape and dimensions, and apparently also in the pattern of the canals and pores. Those of the Infra-Lias specimens are finer and longer than in the Aptian form, which is here regarded as a separate species. Cuvillier states that he is not able to establish the nature of these fossils in a satisfactory manner but suggests that they might represent remains of primitive Charophyta(?).

From these European records it appears that *Favreina* has a life-range from at least the Infra-Lias to the Aptian. In Cuba, typical representatives of both species of *Favreina* are associated in limestones, the age of which is established as middle to upper Portlandian by ammonites and microfossils. This age determination agrees with that reported from the Jura Mountains and from Provence, southern France. The contemporaneous occurrence in Europe and in Cuba indicates that *Favreina* has a world-wide distribution and that it can be used for intercontinental correlation.

Genus incertae sedis

Favreina, new genus

"Organisme B" of authors.
"Characé primitive(?)," Cuvillier, 1951.

Genotype: Favreina joukowskyi Bronnimann, n. sp. (="organisme B" of Joukowsky and Favre); Infra-Lias to Portlandian.

Definition: Subrectangular and rounded dark fragments of apparently homogeneous texture, ranging from about 0.5 to 1.5 mm. in length and from about 0.2 to 0.4 mm. in width. Longitudinal sections subrectangular, with long, thin, straight, parallel canals arranged in a regular intermittent pattern. Transverse sections of subcircular to oval outline; canals represented by minute subcircular to eye-shaped pores, either arranged in two or more flattened oblong rings, or distributed more or less irregularly. Fine lines connect the pores. Diameter of the pores is from 12μ to 40μ.

Remarks: The genus is named for J. Favre, who was one of the first to study the problematic fossils of the Jurassic and to recognize their stratigraphic significance. It has been recorded from the Jura Mountains in Switzerland and France; Provence; Aquitaine; the northern Pyrenees; and Cuba. Infra-Lias to Aptian.

Favreina joukowskyi, new species
Plate 2, figure 11; Text-figure 5e-n

"Organisme B," Joukowsky and Favre, 1913, Soc. Phys. Hist. Nat. Genève, Mém., vol. 37, no. 4, p. 315, pl. 14, fig. 1.—Tutein Nolthenius, 1921, Beitr. Geol. Karte Schweiz, no. 78, pt. 1, p. 16, figs. f-h, k-l (*fide* Favre and Richard, 1927).—Favre and Richard, 1927, Schweiz. Pal. Ges., Abh. (Soc. Pal. Suisse, Mém.), vol. 46, art. 3, p. 36, fig 12. —Pfender, 1927, Soc. Géol. France, Bull., ser. 4, vol. 27, p. 92, pl. 5, fig 6.
"Characé primitive(?)," Cuvillier, 1951, *Corrélations stratigraphiques par microfaciès en Aquitaine occidentale,* pl. 4, fig. 2.

Holotype: The transverse section in the upper part of figure 1 on plate 14 in Joukowsky and Favre (1913) is here designated as holotype of *Favreina joukowskyi* Bronnimann, n. sp.; upper Portlandian.

Description: Subrectangular and rounded dark organic remains of homogeneous texture; length from about 0.5 mm. to 1.5 mm., width from about 0.2 mm. to 0.4 mm. Longitudinal section with long, thin, parallel canals distributed in a regular intermittent pattern. Vertical section shows fine pores arranged in two or more flattened, oblong rings (text-fig. 5k-n).

Comparisons: F. joukowskyi n. sp. differs from *F. cuvillieri* n. sp. in the long, subrectangular shape of the fragments in longitudinal section, in the more delicate and more numerous canals and pores, and in the distinctly regular, ring-like distribution of the pores in transverse section.

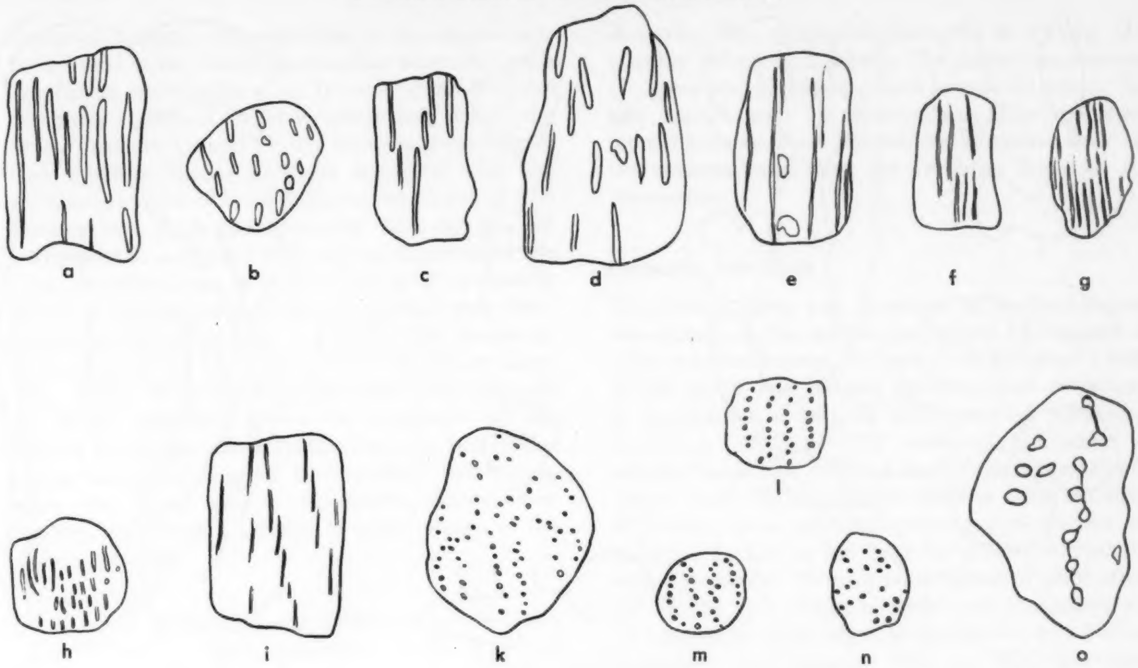
Remarks: Favreina joukowskyi n. sp. has been reported from the upper Portlandian and Infra-Lias of southern Europe. It also occurs in the middle to upper Portlandian of Las Villas Province, Cuba. The species is named for E. Joukowsky.

Favreina cuvillieri, new species
Text-figure 5a-d, o

"Characé primitive(?)," Cuvillier, 1951, *Corrélations stratigraphiques par microfaciès en Aquitaine occidentale,* pl. 17, fig. 1.

Holotype: The largest specimen on the right-hand side of figure 1 on plate 17 in Cuvillier (1951) is here designated as holotype of *Favreina cuvillieri* Bronnimann, n. sp. Garlin (B.-P.) well no. 2, at 2590 meters; middle to upper Aptian.

Description: Subangular to rounded dark organic fragments of homogeneous texture; maximum diameter ranging from about 0.2 mm. to about 1.1 mm. The longitudinal and vertical sections show short and relatively wide canals and rounded to eye-shaped pores, which are occasionally arranged in rows but



TEXT-FIGURE 5

All specimens are from the middle Portlandian of Las Villas Province, Cuba. All × 33. a-d, o, *Favreina cuvillieri* Bronnimann, n. sp., CUGOC Ser. Nos. 20300 and 20358; e-n, *Favreina joukowskyi* Bronnimann, n. sp., CUGOC Ser. Nos. 20300, 20358, and 20582(4).

as a rule without a distinct pattern. The pores appear to be interconnected by fine lines (text-fig. 5o). The pores have a maximum diameter of about 40μ.

Comparisons: The differences between *F. cuvillieri* and *F. joukowskyi* have already been given under the latter species.

Remarks: Favreina cuvillieri was originally reported from the middle and upper Aptian of Aquitaine; it also occurs associated with *F. joukowskyi* in the Portlandian, and doubtfully in the Lower Cretaceous (Barremian to Aptian) of Cuba. It is named for J. Cuvillier.

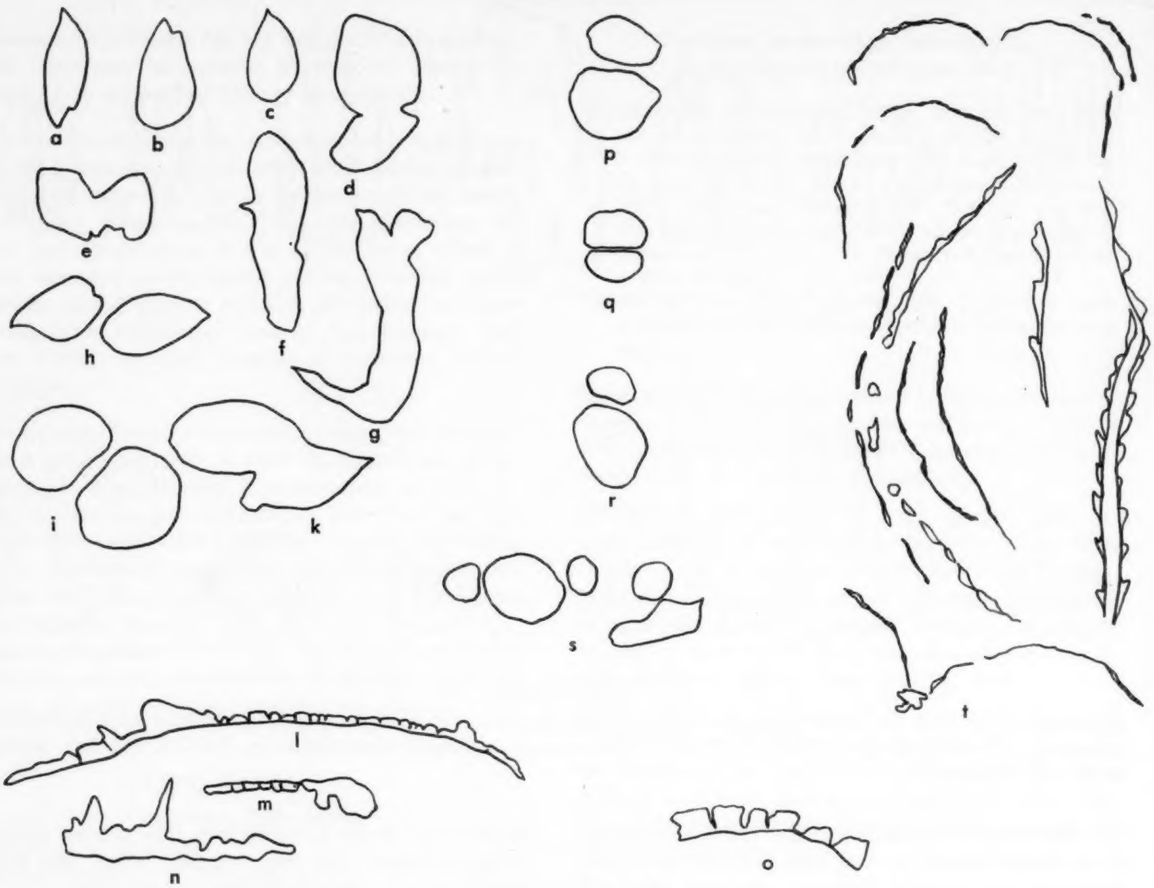
FOSSIL CHLOROPHYCEA(?)

Certain Problematica of the Alpine Upper Jurassic were first described by Lombard (1938), who followed Joukowsky and Favre's terminology, as "organisme D," "formes connexes," and "formes découpées."

For most of the forms grouped in 1938 under "organisme D," Lombard (1945, pp. 166, 170) proposed the name *Globochaete alpina*. For a former subgroup of "organisme D," the "formes fixées," he proposed the name *Eothrix alpina*. Lombard (1945) assigned these simple forms to the Chlorophycea. The present writer is not convinced that they represent algae, and still regards their systematic position as enigmatic.

G. alpina and *E. alpina* are widely distributed, and apparently restricted to beds of Upper Jurassic to Neocomian age. They have been recorded from the Alps, from the Baleares, and from Misoöl, Indonesia. In Cuba, these micro-organisms occur sometimes in great numbers, but are never rock-forming. They are present in otherwise uncharacteristic dense radiolarian limestones interbedded with pseudoölitic to oölitic limestones that carry a rich middle Portlandian fauna. This consists of: *Clypeina jurassica* Favre, *Conicospirillina basiliensis* Mohler, "*Coscinoconus*" *alpinus* Leupold, "*Coscinoconus*" *elongatus* Leupold, *Favreina cuvillieri* Bronnimann, n. sp., *Favreina joukowskyi* Bronnimann, n. sp., *Nautiloculina oolithica* Mohler, *Pseudocyclammina* cf. *P. lituus* (Yokoyama).

G. alpina and *E. alpina* have also been encountered in the dense, finely pseudoölitic limestones of the uppermost Portlandian to lower Neocomian, where they are associated with *Nannoconus* spp., calpionellids, Radiolaria, ostracodes, and aptychi and other ammonite remains.



TEXT-FIGURE 6

All specimens are from the middle Portlandian of Las Villas Province, Cuba. All × 93. a-k, o, p-s, *Globochaete alpina* Lombard, CUGOC Ser. Nos. 21044, 21028, 21072, and 21205; l-n, *Eothrix alpina* Lombard?, CUGOC Ser. No. 21017; t, group of aptychi, CUGOC Ser. Nos. 21017 and 21020.

Globochaete alpina Lombard
Text-figure 6a-k, o-s

"Organisme D," LOMBARD, 1938, Eclogae Geol. Helv., vol. 30, no. 2, p. 321, text-fig. p. 325, pl. 19 (part).—VOGLER, 1941 (*fide* LOMBARD, 1945, p. 163).—STAEGER, 1944 (*fide* LOMBARD, 1945, p. 163).

Globochaete alpina LOMBARD, 1945, Eclogae Geol. Helv., vol. 38, no. 1, p. 166, text-figs. 1, 2.—WEISS, 1949, *Stratigraphie und Mikrofauna des Klippenmalm* (listed only).—PUGIN, 1952, Eclogae Geol. Helv., vol. 44, no. 2 (listed only).

Definition: Lombard (1945, p. 166) defines *G. alpina* as follows:

"Cet organisme, à son stade de maturité, se présente comme une tortue dont le dos et le ventre sont renflés et souvent bilobés. Elle est subsphérique ou très aplatie, avec des états intermédiares. C'est une cellule isolée ou aggrégée à d'autres en chapelet.

"Sa constitution n'apparaît que lorsque certaines zones internes s'altèrent. Il subsiste alors une membrane carbonatée et un intérieur de calcite claire qui est l'ancien protoplasme.

"La pigmentation résultant de l'altération s'étend dans la zoospore, mais s'arrête à la membrane qui reste claire. La membrane est tantôt mince, tantôt épaisse; ce dernier cas est plus rare. Elle est partiellement sclérosée, tendant à former un test que met en valeur l'altération interne. Il est très rarement visible en lumière naturelle ou polarisée. Il est double: un test interne et un test externe, partiellement emboités l'un dans l'autre."

Remarks: Typical representatives of *G. alpina* have been found in the middle Portlandian associated with *Lombardia arachnoidea* n. sp. In some of the doubtful zoospores a distinct radial structure was noted; the radial lines are formed by the linear arrangement of dark particles similar to those described from the spinose extensions of *Lombardia arachnoidea* n. sp. The remains here illustrated in text-fig. 6a-k and p-s are interpreted as zoospores of *G. alpina*. A portion of the base, or substratum as it is called by Lombard, is shown in text-fig. 6o; it is almost identical with Lombard's no. 23 of text-fig. 1 (1945). The maximum dimensions of the zoospores range from 70μ to about 200μ. These measurements correspond with those of the larger specimens drawn by Lombard. All the figured specimens are of Portlandian age, but similar forms, except remains of the so-called substratum, have also been seen in Neocomian *Nannoconus*-bearing limestones. *G. alpina* is rather scarce in the Cuban material.

Eothrix alpina Lombard?
Text-figure 6l-n

"Formes fixées," LOMBARD, 1938, Eclogae Geol. Helv., vol. 30, no. 2, p. 325, pl. 19, figs. 181, 182, 186, 206.

Eothrix alpina LOMBARD, 1945, ibid., vol. 38, no. 1, p. 170, text-fig. 3, nos. 47-49.—WEISS, 1949, *Stratigraphie und Mikrofauna des Klippenmalm* (listed only).—PUGIN, 1952, Eclogae Geol. Helv., vol. 44, no. 2 (listed only).

Definition: Lombard (1945, p. 170) defines *E. alpina* as follows:

> "Ce sont des rangées linéaires de cellules, de dimensions allant de 5 à 10μ de diamètre. Le grand axe de chaque cellule est perpendiculaire à la rangée. En d'autres termes, elles sont plus larges que longues. Les filaments qu'elles forment ne sont jamais bifurqués, souvent rectilignes et rarement arqués.
>
> "De temps à autre, une cellule apparaît plus grande que les autres, tachée de pigments sombres. Sa présence permet de déterminer sans erreur la nouvelle forme d'*Eothrix* dans une coupe mince. Un autre caractère est la symétrie des petites cellules par rapport au grand axe du filament. Ces petites cellules peuvent exceptionnellement se développer sur deux rangs. Ce sont des cellules végétatives alors que les grands individus sont des cellules en voie de reproduction.
>
> "Dès que la série cellulaire se développe asymétriquement, c'est qu'on retrouve une chaînette de *Globochaete* sur son substratum.
>
> "C'est ainsi que l'on distingue *Eothrix* de *Globochaete* dans certains cas de convergences.
>
> "Les zoospores ne sont pas toutes de même taille mais reposent sur une base uniforme, d'où l'asymétrie."

Remarks: The specimens illustrated in text-fig. 6l-n possibly belong to *E. alpina*. The distinction between *G. alpina* and *E. alpina* cannot always be made. The two species may be synonymous. The specimens figured here are from Portlandian limestone; they are not common, and have not yet been found in the Neocomian.

LOMBARDIA, NEW GENUS

The most striking and abundant of the problematic microfossils in the middle and upper Portlandian of Cuba are the "formes découpées" of Lombard (1938, p. 326, pl. 19, figs. 230-236, 240-243), here introduced as *Lombardia* n. gen. In well-preserved specimens, Lombard (1945, p. 171) observed indications of cellular tissue, and referred these peculiar remains to larger algae. He mentioned affinities with the thalli of Ulvales; those of Pteridophyta and of Fucales are regarded by him as too large for a close relationship with *Lombardia*. There is no evidence of plant structure in the rich Cuban material, and the assignment of *Lombardia* to the algae is questioned. Also Paréjas' suggestion (in Lombard, 1938, p. 326) that these microfossils might be derived from sponge skeletons can be discarded as improbable. On the other hand, the comparison of these enigmatic remains with the calcareous bodies of Recent and fossil holothuroids illustrated by Ludwig (1892; 1894) and by Croneis and McCormack (1932) shows that many representatives of *Lombardia*, at least from their outlines, could be randon sections of microscopic symmetrical holothurian remains. *Lombardia* could also be related to microscopic planktonic crinoids such as those described by Peck (1943) from the Lower Cretaceous of Texas. Thin sections of Upper Cretaceous ophiuroid parts from Texas display a close morphologic affinity with *Lombardia*. Its probable affinity with the echinoderms is further supported by the characteristic symmetry of most of the remains (pl. 1, figs. 18-20), by the existence of rounded holes in some of the illustrated specimens of *L. perplexa* n. sp. (text-fig. 9), and by the association with perforated calcareous plates of holothuroid type in some of the middle Portlandian thin sections. Free Jurassic holothuroid or crinoid material was not available, and the supposed relationship with *Lombardia* could not be verified. Thus, the systematic position of the new genus is still somewhat doubtful. In the Cuban material, *Lombardia* is represented by three distinct morphologic groups characterized by common features, such as symmetry, texture, preservation, etc. These three groups are described as species of *Lombardia*, although the possi-

bility cannot be excluded that they may originate from the same organism.

Genus incertae sedis

Lombardia, new genus

"Formes découpées," LOMBARD, 1938, Eclogae Geol. Helv., vol. 30, no. 2, pl. 19, figs. 230-236, 240-243.
"Sections de thalles," LOMBARD, 1945, ibid., vol. 38, no. 1, p. 171, text-fig. 3, nos. 58-65.

Genotype: Lombardia arachnoidea Bronnimann, n. sp., middle to upper Portlandian, Las Villas Province, Cuba.

Definition: Free, calcareous, transparent microfossils that are spined, broad-branching, or angularly bone-shaped. All are symmetrical. Central body of variable size and shape; of granular aspect by accumulation of minute, dark, angular fragments. No cellular structure or suggestions of plant organization have been seen. Arm-like extensions of the spined and of the angular bone-shaped types with a dark median line, composed of the same tiny dark particles as can be found in the central body. Spines and branches are divided into more or less regular intervals by sharp, dark lines parallel to the central axis. They extend slightly into the surrounding, finely crystalline matrix, and therefore are interpreted as fractures. Similar but longer lines cut across the central body. Maximum diameter of the figured specimens ranges up to about 1.5 mm.

Remarks: The tests have been divided into three groups of morphologically related forms. As a rule, they are associated. Separated remains, which may belong together, sometimes occur in small groups (text-fig. 10a-c), indicating that they may be from the same organism. The vertical distribution is irregular, and the three groups could not be used for a more detailed zonation.

The genus is named for A. Lombard, who first described these remains from the Alpine Malm.

Lombardia arachnoidea, new species
Plate 1, figures 18-20, 24(?); Text-figures 7, 8

Holotype: Lombardia arachnoidea Bronnimann, n. sp., pl. 1, fig. 19, from CUGOC Ser. No. 21141(3), Las Villas Province, Cuba; middle Portlandian.

Description: The symmetrical test consists of a central body and long spine-like extensions. Form and dimensions of the central body are variable. The extensions show a dark median line composed of the same type of tiny dark particles that occur irregularly distributed in the central body. The test is cut at more or less regular intervals by sharp fractures, which run parallel to its axis. The maximum diameter ranges from 0.1 mm. to about 1.5 mm.

Comparisons: L. arachnoidea differs from *L. perplexa* in its thin, long, spine-like arms, and from *L. angulata* in the gently curved extensions and in the absence of the terminal thickenings of the bodies and branches.

Remarks: Of the three types, *L. arachnoidea* is the most common, it has been found in virtually all the middle and upper Portlandian *Lombardia*-bearing limestones of Las Villas Province, Cuba. This is of interest, because it was not figured by Lombard (1938), excepting perhaps the specimen represented by figure 232 of plate 19.

Lombardia perplexa, new species
Plate 1, figure 22; Text-figure 9

"Formes découpées," LOMBARD, 1938, Eclogae Geol. Helv., vol. 30, no. 2, pl. 19, figs. 230, 231.

Holotype: Lombardia perplexa Bronnimann, n. sp., text-fig. 9i, from CUGOC Ser. No. 21019, Las Villas Province, Cuba; middle Portlandian.

Description: The symmetrical test is characterized by broad areal branches of irregular outline. The central position and parts of the branches are sometimes irregularly perforated by large rounded holes. The maximum diameter ranges from 0.2 mm. to 1.5 mm.

Comparisons: The irregular outlines, the broad branches, and the perforations distinguish *L. perplexa* from other species of *Lombardia.*

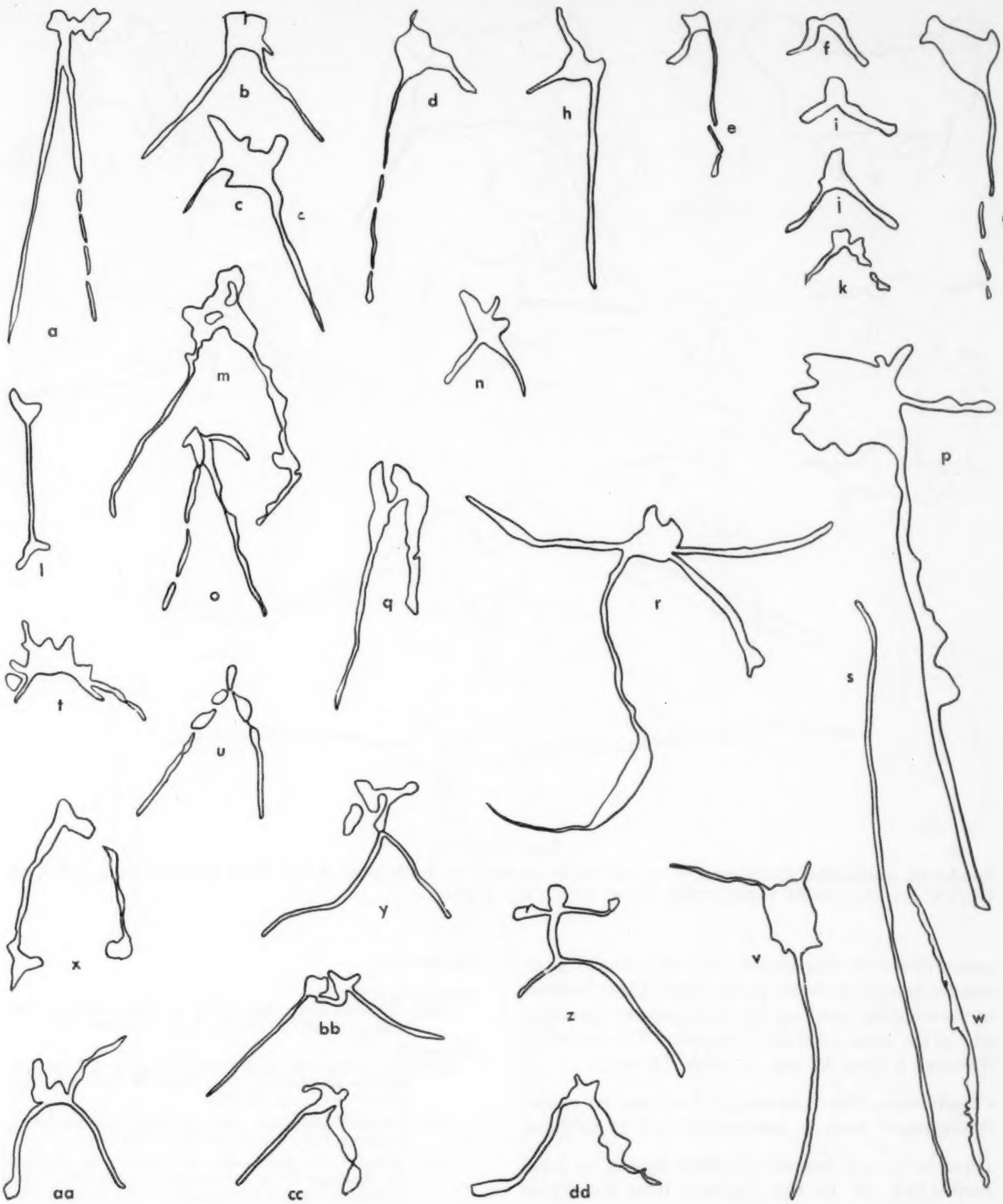
Remarks: L. perplexa was originally figured by Lombard (1938, pl. 19, figs. 230, 231). This relatively rare species occurs in the middle and upper Portlandian of Las Villas Province, Cuba, and in the Upper Jurassic of Switzerland and of Haute Savoie in France.

Lombardia angulata, new species
Plate 1, figure 23; Text-figure 10

"Formes découpées," LOMBARD, 1938, Eclogae Geol. Helv., vol. 30, no. 2, pl. 19, figs. 234(?), 235, 236(?), 240-243.
"Sections de thalles," LOMBARD, 1945, ibid., vol. 38, no. 1, text-fig. 3, nos. 58(?), 60, 61, 64.

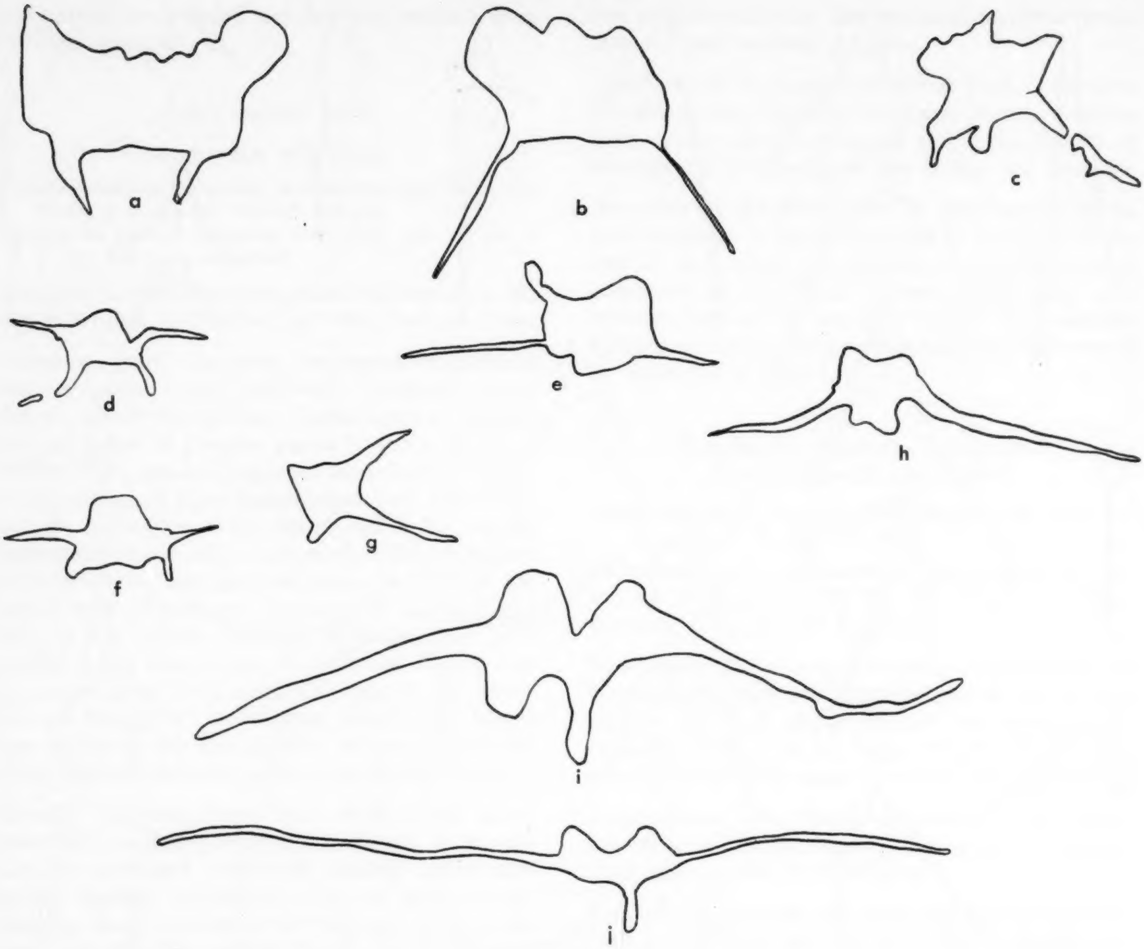
Holotype: Lombardia angulata Bronnimann, n. sp., text-fig. 10h, from CUGOC Ser. No. 21141, Las Villas Province, Cuba; middle Portlandian.

Description: The symmetrical test is bone-shaped with enlarged end-portions, or composed of two parts meeting in a pointed angle or of two parallel-running thin branches, or irregularly angular. As a rule, the branches are straight and of equal thickness. Speci-



TEXT-FIGURE 7

Lombardia arachnoidea Bronnimann, n. sp. All specimens from the Portlandian of Las Villas Province, Cuba. All × 93. CUGOC Ser. Nos. 13500, 20432, 21019, 21024, 21025, 21029, 21045, 21046, 21047, and 21071.



TEXT-FIGURE 8

Lombardia arachnoidea Bronnimann, n. sp. All specimens from the Portlandian of Las Villas Province, Cuba. All × 93. CUGOC Ser. Nos. 21025, 21028, 21029, 21046, 21071, and 21139.

mens referred to this species may be arranged in irregular groups, as shown in text-figure 10a-c. Sections of the complete fossil exhibit the symmetry characteristic of the genus (text-fig. 10f-h, k-m). The maximum diameter is from 0.2 mm. to about 1.0 mm.

Comparisons: The bone-shaped tests can be clearly distinguished from *L. arachnoidea* and *L. perplexa.*

Remarks: L. angulata was originally figured by Lombard (1938, pl. 19, figs. 240-243) from the Alpine Upper Jurassic. In the Cuban material it is more common than *L. perplexa* but not as frequent as *L. arachnoidea.* It has been found in the middle and upper Portlandian of Las Villas Province, Cuba.

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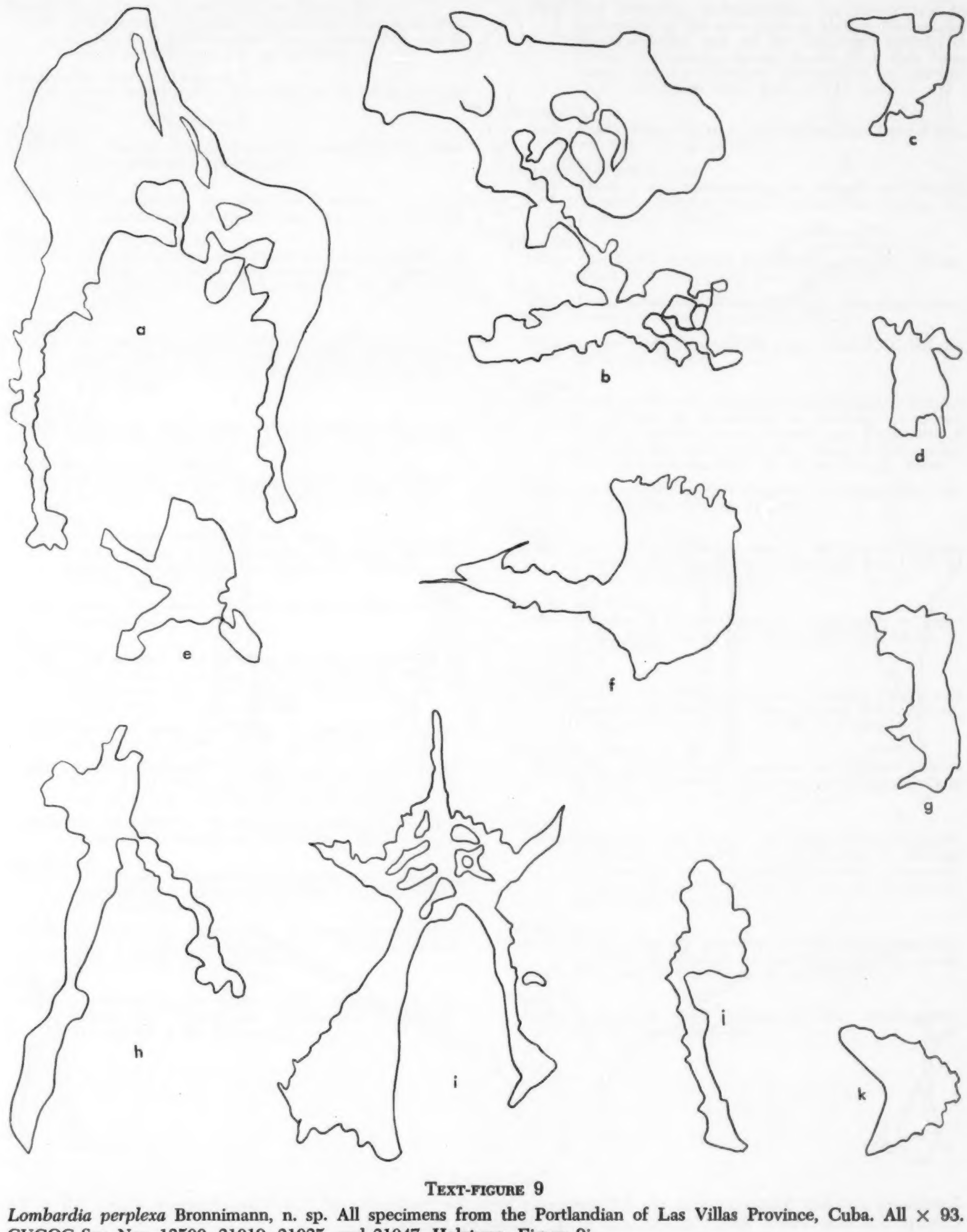
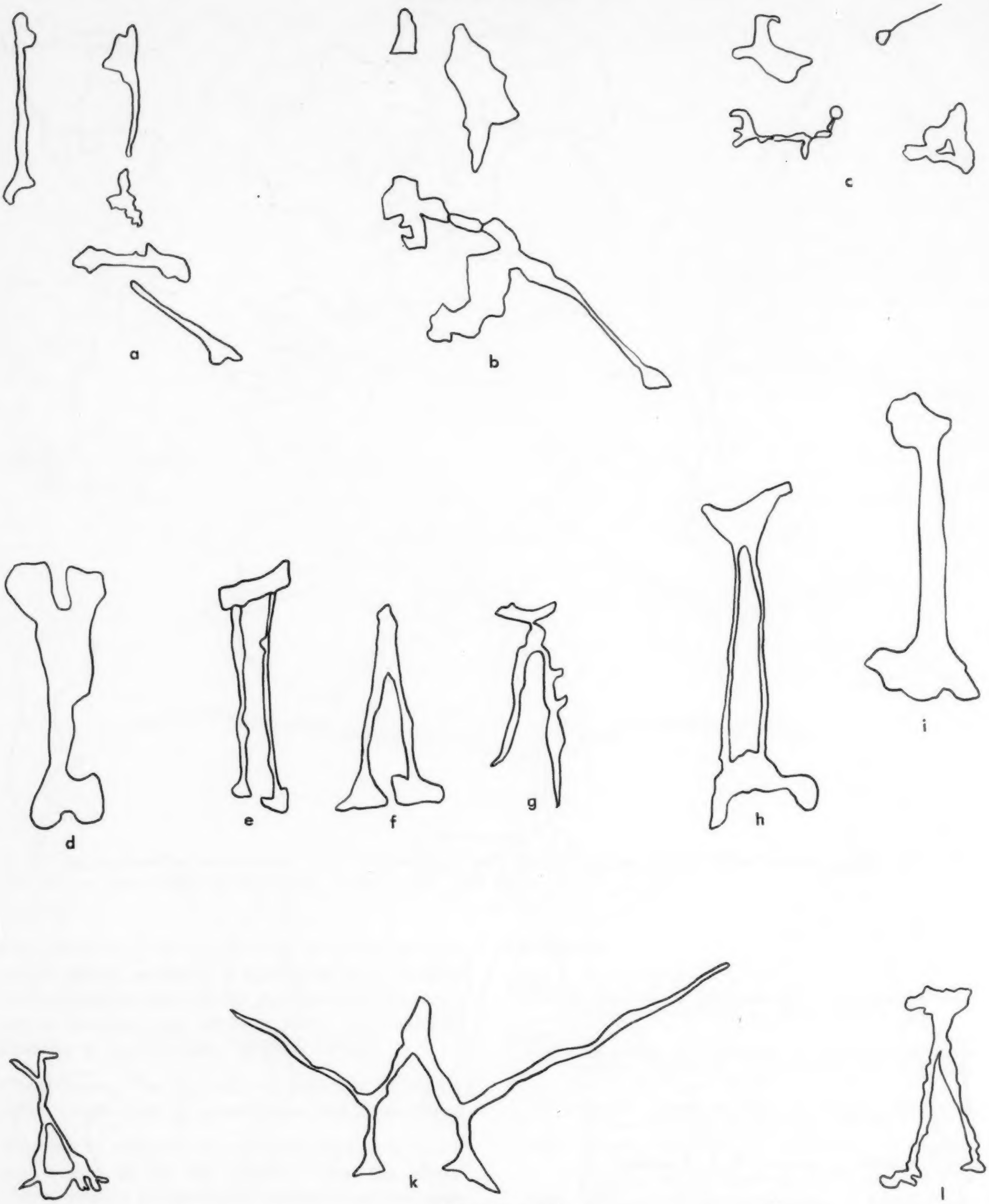


TEXT-FIGURE 9

Lombardia perplexa Bronnimann, n. sp. All specimens from the Portlandian of Las Villas Province, Cuba. All × 93. CUGOC Ser. Nos. 13500, 21019, 21025, and 21047. Holotype: Figure 9i.



TEXT-FIGURE 10

Lombardia angulata Bronnimann, n. sp. All specimens from the Portlandian of Las Villas Province, Cuba. All × 93. CUGOC Ser. Nos. 13500, 21071, 21131, and 21141. Holotype: Figure 10h.

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PLATE 1

Figures 1-3, 5-7 *Nannoconus bucheri* Bronnimann, n. sp.

Lower Cretaceous, CUGOC Ser. No. 21492(3), Las Villas Province, Cuba. × ca. 1575. Figures 1 and 3 show the granular inner surface of the cavity; the individual wedges and their spiral arrangement are clearly visible. Figure 5 is a tangential view, parallel to the axis. Figure 6 is an almost-centered section of the same specimen as in figure 5; it shows the two opposite terminal apertures. Figure 2 is a centered axial section of the same specimen as in figure 3. Holotype: Figure 2.

4, 8, 9, 15, 17, 21 *Nannoconus wassalli* Bronnimann, n. sp.

Lower Cretaceous, CUGOC Ser. No. 20245(1), Las Villas Province, Cuba. × ca. 1575. Figures 17 and 21 are somewhat tangential sections and therefore less typical and could be mistaken for *N. bucheri*. Figure 15 is a transverse section. Holotype: Figure 8.

10-14 *Nannoconus elongatus* Bronnimann, n. sp.

Lower Cretaceous, Las Villas Province, Cuba: 10-13, CUGOC Ser. No. 21492(3); 14, CUGOC Ser. No. 20942(2). 10, 11, 14 × ca. 1575; 12, 13, × ca. 900 (slightly retouched). Holotype: Figure 10.

16 *Nannoconus steinmanni* Kamptner

Lower Cretaceous, CUGOC Ser. No. 20843(2), Las Villas Province, Cuba. × ca. 1575 (slightly retouched).

18-20, 24(?) *Lombardia arachnoidea* Bronnimann, n. sp.

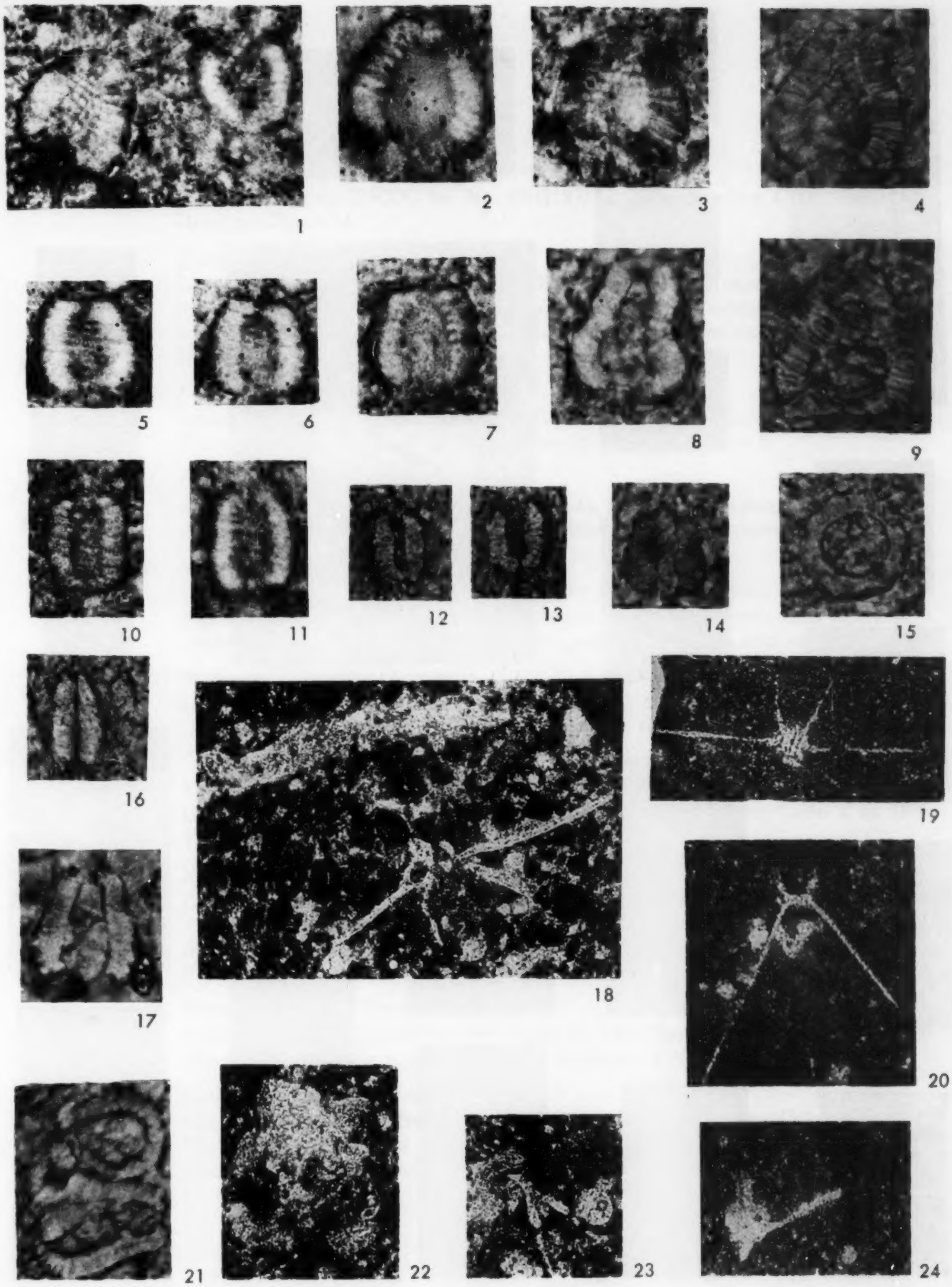
Middle Portlandian, Las Villas Province, Cuba: 18, CUGOC Ser. No. 21150(1); 19, 20, 24, CUGOC Ser. No. 21141(3). × 52. Holotype: Figure 19.

22 *Lombardia perplexa* Bronnimann, n. sp.

Middle Portlandian, CUGOC Ser. No. 21150(1), Las Villas Province, Cuba. × 52.

23 *Lombardia angulata* Bronnimann, n. sp.

Middle Portlandian, CUGOC Ser. No. 21150(1), Las Villas Province, Cuba. × 52.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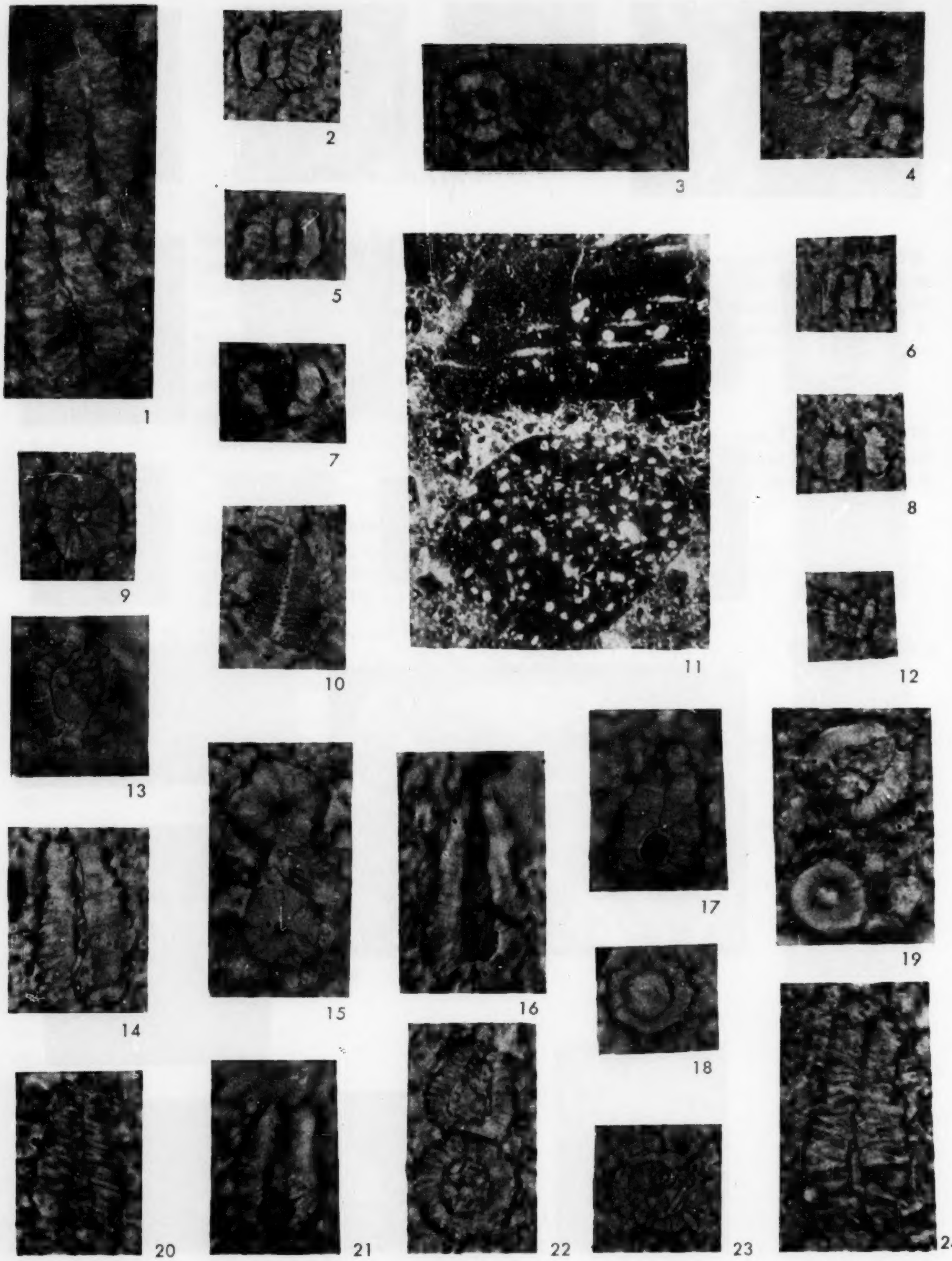
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PLATE 2

Figures 1, 24 *Nannoconus bermúdezi* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 20942(2), Las Villas Province, Cuba. × ca. 1575. Holotype: Figure 24.

2-5, 7 *Nannoconus truitti* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 13152(2), Las Villas Province, Cuba. × ca. 1575. Figure 3 shows a transverse and a good axial section which exhibits the two terminal apertures. The wall structure and the spiral arrangement can be seen in figures 2 and 4. Holotype: Figure 2.

4, 6, 8, 12 *Nannoconus minutus* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 13152(2), Las Villas Province, Cuba. × ca. 1575. The wall structure is clearly visible in figure 12. Holotype: Figure 8.

11 *Favreina joukowskyi* Bronnimann, n. sp.
Middle Portlandian, CUGOC Ser. No. 20582(4), Las Villas Province, Cuba. × 52. The photograph shows a longitudinal section (above) and a transverse section (below).

9, 17 *Nannoconus colomi* (de Lapparent)
Lower Cretaceous, CUGOC Ser. No. 22082(1), Las Villas Province, Cuba. × ca. 1575. Figure 9 illustrates a transverse section across the bulbous cavity, and figure 17 a longitudinal section with the basal bulbous cavity and the thin axial canal.

10, 15 *Nannoconus steinmanni* Kamptner
Lower Cretaceous, Las Villas Province, Cuba: 10, CUGOC Ser. No. 20942(2); 15, CUGOC Ser. No. 22082(1). × ca. 1575. Figure 10 is a longitudinal section (slightly retouched); figure 15 shows two transverse sections.

13, 18, 23 *Nannoconus globulus* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 22082(1), Las Villas Province, Cuba. × ca. 1575. The figures are slightly retouched.

14, 16, 20, 21 *Nannoconus kamptneri* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 21566(1), Las Villas Province, Cuba. × ca. 1575. The photographs are all from longitudinal sections exhibiting the wide axial canal and the wedge structure of the walls. They are in part slightly retouched. Holotype: Figure 16.

19 *Nannoconus bucheri* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 13152(2), Las Villas Province, Cuba. × ca. 1575. The transverse section is probably from a specimen of *Nannoconus truitti*.

22 *Nannoconus wassalli* Bronnimann, n. sp.
Lower Cretaceous, CUGOC Ser. No. 20245(1), Las Villas Province, Cuba. × ca. 1575. The longitudinal and the circular transverse sections are from specimens of *Nannoconus wassalli*. The longitudinal section is somewhat tangential, and could be mistaken for *N. bucheri*.

ABSTRACT: *A new lithostratigraphic unit in the Upper Cretaceous of north-central Venezuela is named and defined as the Escorzonera formation. The age of this formation has been established as Maestrichtian from the occurrence of a number of species of larger foraminifera. Certain interesting foraminifera from the Morro del Faro member of the Guárico formation are also included, since they help to define the age of the large morros of San Juan as Paleocene, contrary to recently expressed opinion that they may be of Cretaceous age. The genus* Laffitteina *is reported for the first time from the Western Hemisphere.*

Some Upper Cretaceous and Lower Tertiary foraminifera from Aragua and Guárico, Venezuela

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INTRODUCTION

In a recent publication, M. de Cizancourt (1949, pp. 670-671) reported an interesting fauna of Upper Cretaceous larger foraminifera, collected by J. Schoeffler from the San Sebastián area, State of Aragua, Venezuela. The fauna was contained in a gray compact limestone (sample L-2) to which no formation name was assigned. The occurrence of the genera *Vaughanina* Palmer, *Omphalocyclus* Bronn, and *Sulcoperculina* Thalmann indicates a Maestrichtian age, and de Cizancourt suggested correlation with the Habana formation of Cuba.

During a recent geological field survey of the San Juan de Los Morros — San Sebastián area carried out by Dr. P. Leuzinger for the Mene Grande Oil Company, a number of rocks were collected which contained essentially the same fauna as that described from the same general area by de Cizancourt. For this rock-unit, Leuzinger introduces the name Escorzonera formation and gives the following definition:

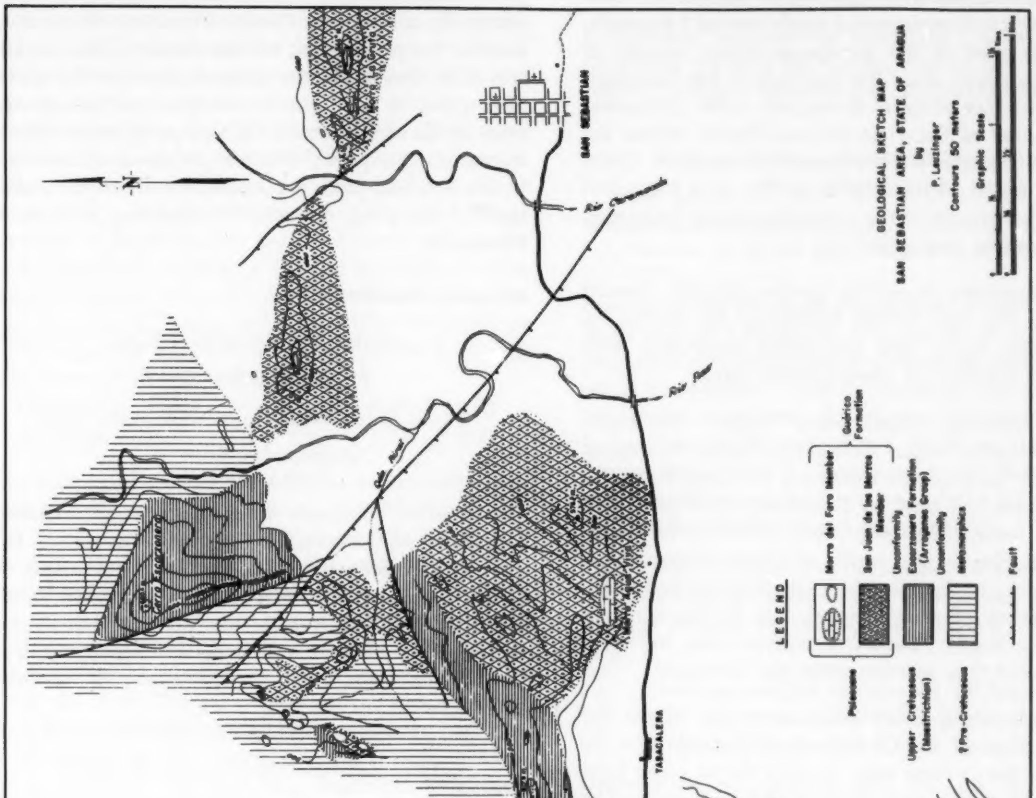
"The formation derives its name from Cerro Escorzonera where the type locality is situated. It lies about four kilometers northwest of the town of San Sebastián, State of Aragua (text-fig. 1). Here, the formation is 450 meters thick and transgresses, with an angular unconformity, on the early Cretaceous or pre-Cretaceous metamorphic rocks. It is overlain, with a slight unconformity, by the Paleocene Guárico formation.

"On lithological grounds, the formation can be divided into two members. The lower member, about 300 meters thick, consists of a sequence of shales, sandstones and limestones, interbedded with lava. At the base of the member a body of andesitic pillow lava frequently occurs, followed by a conglomeratic limestone with reworked pebbles of andesite and metamorphic rocks. This is overlain by a sequence of greenish sandstones, dark red sandstones, and impure limestones, containing lava particles. These beds are followed by impure brownish-green shales containing some harder beds filled with lava material. The upper member, about 150 meters thick, is in transitional contact with the lower member. Farther west, for example north of the Morro Quebrada Honda, it overlaps the metamorphic series with the development of a conglomerate at the base containing pebbles of andesite and metamorphic rocks. At Cerro Escorzonera, the upper member consists of well-bedded greenish gray limestones, forming beds from 10 centimeters to 1 meter thick, with reworked green lava material. These limestones are interbedded with greenish silty and micaceous foliated shales. Locally, the sequence grades laterally into black and olive shales containing iron claystone nodules and siltstone beds with practically no limestone. The top of the Escorzonera formation is covered by andesitic lava or by the transgressive Guárico formation."

The Escorzonera formation can be followed from Cerro Escorzonera to the southwest, over a distance of about 7 kilometers. It occurs again in the San Juan de Los Morros area, unconformably underlying the Guárico formation, east and west of the large morros. The Escorzonera formation includes beds with *Trochactaeon* and reworked Cenomanian ammonites *(Hypoturrilites)*. The larger foraminifera described by C. M. B. Caudri (1944) definitely come from the overlying San Juan de Los Morros member of the Guárico formation.

It is suggested that the Escorzonera formation be included in the upper part of the Arrayanes group of

 micropaleontology, vol. 1, no. 1, pp. 52-71, pls. 1-8, text-fig. 1, january, 1955



TEXT-FIGURE 1
Geological sketch map of the San Sebastián area, State of Aragua

E. Mencher et al. (1953, pp. 701, 775). The name Arrayanes is applied to the Upper Cretaceous sedimentary volcanic sequence of north-central Venezuela. The lower part of the Arrayanes group consists of beds outcropping along the San Juan — San Sebastián road, at the foot of Cerro Garrapata, a few kilometers east-northeast of San Juan de Los Morros, where the Coniacian ammonite *Peroniceras* cf. *moureti* Degr. has been found (Bucher, 1952, p. 52). It is suggested that this lower part of the Arrayanes group be named the "Garrapata formation."

The Escorzonera formation grades laterally toward the south into the Vidoño formation, by way of an intermediate facies also containing limestones with larger foraminifera of Maestrichtian age.

In the following pages, some Upper Cretaceous (Maestrichtian) larger foraminifera from the upper part of the Escorzonera formation are described. The samples were collected, by Leuzinger's field party and by H. H. Renz, from Paso Copey, north of the Morro Quebrada Honda and south of Cerro Copey (text-fig. 1). Most of the identifications were made from a great number of rock sections, but during a recent visit to the locality, some free material was collected, and oriented thin sections were also prepared.

A few interesting foraminifera from the Morro del Faro member of the Guárico formation are also included in the present note, as they throw some light on the age of the great morros of San Juan de Los Morros, for which Kugler (1953, pp. 41-42) recently suggested a Cretaceous age. As these specimens were collected on top and from the vertical wall of the great morros of San Juan, there can scarcely be any doubt that these limestones are younger than Cretaceous and most probably are Paleocene.

In thin section, the rock of the Escorzonera formation, in which the larger foraminifera occur, has the appearance of a finely conglomeratic, yellowish limestone with reworked pebbles of lava and metamorphic rocks. The limestone is packed with larger foraminifera, especially the genera *Sulcoperculina*, *Vaughanina*, *Lepidorbitoides* (*Asterorbis*), *Pseudorbitoides* and *Omphalocyclus*. Globigerinidae, Rotaliidae, Miliolidae, *Gümbelina* sp., and various species of *Globotruncana*, particularly *G. conica* var. *plicata* White, are quite common, in addition to algae (*Archaeolithothamnium*, *Corallina*) echinoid spines, mollusk remains and bryozoa. The larger foraminifera, as well as the algae, are often broken, probably due to the strong wave action along the coast of metamorphic rocks on which the Escorzonera formation overlaps.

Thanks are due to Professor M. Reichel (Basel), who gave valuable advice with respect to some of the identifications, and to Mr. George Fournier, who lent his skill in the preparation of the oriented thin sections and who also made the photographs for the plates. The writer is also greatly indebted to the management of the Mene Grande Oil Company for permission to publish this paper. The sample numbers indicated in the text and plate explanations refer to the collections of the Mene Grande Oil Company at Caracas, Venezuela.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA

Family MILIOLIDAE

Genus Quinqueloculina d'Orbigny, 1826

Quinqueloculina sp.
Plate 1, figure 1

The figured specimen was found in the Guárico formation, San Juan de Los Morros member, at El Pao, west of San Sebastián, State of Aragua (Sample B–5086). This form appears to have stratigraphic significance in the correlation of the Guárico formation of the States of Guárico and Aragua. This stratigraphic unit is considered to be predominantly of Paleocene age.

Family NUMULITIDAE

Genus Nummulites Lamarck, 1801

Nummulites tobleri (Vaughan and Cole)
Plate 1, figure 2

Miscellanea tobleri Vaughan and Cole, 1941, Geol. Soc. Amer., Spec. Papers, no. 30, p. 35, pl. 4, figs. 5-7; pl. 7, fig. 1.

Ranikothalia tobleri (Vaughan and Cole).—Caudri, 1944, Bull. Amer. Pal., vol. 28, no. 114, pl. 5, figs. 22, 26(?).

The figured specimen was collected from the vertical walls in the southeast corner of the morros of San Juan (Sample B–5537). This unit belongs to the Morro del Faro member of the Guárico formation, to which a Paleocene age is assigned.

Genus Sulcoperculina Thalmann, 1938

Sulcoperculina globosa de Cizancourt
Plate 1, figures 3-8

Sulcoperculina globosa de Cizancourt, 1949, Soc. Géol. France, Bull., ser. 5, vol. 18, fasc. 8-9, p. 670, pl. 24, figs. 6, 7.

Sulcoperculina globosa de Cizancourt is one of the most common forms among the Venezuelan Maestrichtian material. The species was originally recorded from the same general area, near San Sebastián, State of Aragua.

The test is small, lenticular, strongly umbonate, bilaterally symmetrical or slightly asymmetrical and very thick, the thickness sometimes exceeding the diameter. The surface is smooth and the umbonal area is covered on each side by a large central boss which has a slightly granular appearance and from which radiate straight, smooth to slightly raised sutures; these show occasionally a slight backward curvature near the bluntly rounded periphery. At the periphery of the test there is a V-shaped depression (peripheral canal) bordered on both sides by very fine plates which give it, in equatorial section, a fringed appearance. The diameter ranges from 0.95 mm. to 1.425 mm., and the thickness from 0.75 mm. to 1.05 mm. The relationships of diameter and thickness are shown by the following measurements of four specimens:

Diameter (mm.):	1.0	1.325	0.975	0.95
Thickness (mm.):	0.8	1.05	0.75	0.97

Two equatorial sections through the embryonic chambers of macrospheric tests were available for study. The embryonic chamber is subspherical in shape with internal diameters of 50μ by 38μ, and 38μ by 32μ, respectively. The second chamber has a similar shape and the internal diameters are 57μ by 44μ, and 50μ by 44μ, respectively. The two chambers are separated by an indefinite partition which, in one specimen, is about 10μ thick. The outside wall of the two chambers has a thickness of about 20μ. There are three and one-third and three and three-quarters whorls, respectively, following the first two chambers. Beginning with the final whorl, the last three whorls have twenty-five, nineteen, and fourteen chambers, respectively, per whorl. The chamber septa are thick, double-walled, straight or slightly curved backward, particularly near the periphery; they appear to be hollow, enclosing a distinct canal. The spiral septum shows very fine pectinations between the radial septa.

Vertical sections are very characteristic in their great thickness. The central boss, which is seen externally, is made up of a large number of closely packed hair-like pillars, which begin at the embryonic chambers and thicken, wedge-like, toward the periphery. The closely packed pillars usually cover the central umbonal part of the test but may cover the entire test, thus completely obscuring the internal structure of the test. The radial pillars are usually crossed by hair-like concentric lines. The V-shaped groove in the spiral suture, a very characteristic feature for the genus *Sulcoperculina,* is always visible.

De Cizancourt separated the less inflated and more elongate *S. obesa* from *S. globosa,* although in equatorial section they appear to be absolutely identical. As there are all possible transitions between these two forms, they should probably be considered conspecific.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Samples B-4816, B-6444, B-6451.

Sulcoperculina obesa de Cizancourt
Plate 2, figures 1, 2

Sulcoperculina obesa DE CIZANCOURT, 1949, Soc. Géol. France, Bull., ser. 5, vol. 18, fasc. 8-9, p. 670, pl. 24, figs. 9, 11, 14(?).

Sulcoperculina obesa de Cizancourt is very similar to *S. globosa* de Cizancourt. It is said to be less inflated and more elongate, but this distinction appears weak, since there exists a definite transition between these two forms. Moreover, the equatorial sections appear to be identical. It is suggested, therefore, that, in the future, both forms be combined under the name *S. globosa.* A few vertical sections of the forms called *S. obesa* by de Cizancourt are given here.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Samples B-4816, B-6444, B-6451.

Sulcoperculina dickersoni (Palmer)
var. **vermunti** (Thiadens)
Plate 2, figures 3-8; Plate 3, figure 1

Camerina vermunti THIADENS, 1937, Jour. Pal., vol. 11, no. 2, pp. 94-95, pl. 16, figs. 1, 11, 12; text-figs. 2C, 3A, E.

Camerina dickersoni Palmer.—VOORWIJK, 1937 (part), K. Akad. Wetensch. Amsterdam, Proc. Sect. Sci., vol. 40, pp. 191, 192, pl. 2, figs. 14-16; pl. 3, figs. 3, 6 (not pl. 2, figs. 11-13).

Miscellanea dickersoni (Palmer).—COLE, 1944 (part), Florida, Geol. Survey, Bull., no. 26, pp. 38-39, pl. 21, figs. 9, 11 (not figs. 8, 10).

Operculina (Sulcoperculina) cosdeni APPLIN AND JORDAN, 1945, Jour. Pal., vol. 19, no. 2, pp. 140-141, pl. 20, fig. 2a-c.

Miscellanea dickersoni (Palmer) var. *vermunti* (Thiadens).—COLE, 1947, Bull. Amer. Pal., vol. 31, no. 126, pp. 5-14, pl. 1, figs. 1-9, 14-17; pl. 2, figs. 1-9; pl. 3, figs. 6-10.

Sulcoperculina vermunti (Thiadens).—CAUDRI, 1948, Jour. Pal., vol. 22, no. 4, p. 480, pl. 74, figs. 1, 4, 7.

This form is abundant in the Maestrichtian Escorzonera formation of Venezuela and was identified according to Cole's (1947) criteria which led him to distinguish the two varieties *cubensis* and *vermunti* from the basic form *S. dickersoni* (Palmer). *Operculina (Sulcoperculina) cosdeni* Applin and Jordan is included in the synonymy of the variety *vermunti.*

The Venezuelan representatives of this variety show a great range in size. The diameters vary between 0.55 mm. and 1.7 mm. and the thicknesses of the meas-

ured specimens range from less than 0.5 mm. to almost 0.9 mm. The following table shows the relationships of diameter and thickness (measurements given in millimeters):

Diameter:	0.8	0.975	1.0	1.025	1.075	1.35	1.4	1.45
Thickness:	0.5	0.575	0.6	0.6	0.675	0.7	0.825	0.875

Thus it can be seen that the thicknesses are usually a little more than half the diameter, as is also the case in the specimens measured by Cole (1947) from Cuba (Palmer Station 1214) and Florida.

The test is small, lenticular, thick, umbonate, bilaterally symmetrical or slightly asymmetrical. The central boss, which is slightly elevated, varies greatly in size, even with respect to the ventral and dorsal sides of the same specimen. The radiating sutures, usually starting at the central boss, are straight, sometimes slightly recurving toward the periphery. The periphery, which is narrowly rounded to angular, has in the center a V-shaped canal, bordered on both sides by small, closely packed plates which, in equatorial sections, give the spiral suture a pectinated appearance.

In equatorial section the specimens show two and one-half to three and one-half whorls, with fifteen to twenty chambers in the last whorl. The first two chambers are mostly recrystallized, but in one specimen the first chamber measures 50μ by 38μ and the second chamber 57μ by 44μ. The two chambers are separated by a thin wall. The outside wall of the first two chambers is 18μ to 25μ thick. The radial septa are thick, double-walled, and appear to be hollow, containing a distinct canal. The spiral septum shows fine pectinations between the radial septa.

In vertical sections, the V-shaped groove along the spiral suture is well developed in most specimens. The surface diameter of the central boss ranges from 0.16 mm. to 0.38 mm. The boss is formed by a great number of closely packed hair-like pillars, which begin at or near the first chambers and thicken, wedge-like, toward the periphery. In some specimens, practically no pillars are present.

For comparison, a specimen of S. *dickersoni* var. *vermunti* from Cuba is figured (pl. 2, fig. 8; pl. 3, fig. 1).

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Samples B-4816, B-6444.

Family ROTALIIDAE

Genus **Laffitteina** Marie, 1946

Laffitteina Marie, 1946, Soc. Géol. France, Bull., ser. 5, vol. 15 (1945), fasc. 7-8, p. 430.

Laffitteina sp.
Plate 3, figures 2, 3

As there were only a few vertical sections and pieces of equatorial sections available for study, it is not possible to describe this form fully. Moreover, due to recrystallization, not all the details can be observed satisfactorily, although the generic identification seems to be warranted. This is the first record of the occurrence of the genus *Laffitteina* in the Western Hemisphere. So far, only a very few species of this genus are known, from the Dano-Montian of Algeria, from the Montian of France and French West Africa (Mauritania), and from the Lower Eocene of northern Spain, Iraq and Syria. These occurrences indicate that the genus *Laffitteina* is predominantly a Paleocene form, although it may range from the uppermost Cretaceous (Danian) to the Lower Eocene (Ypresian). In Venezuela, it occurs in the Morro del Faro member of the Guárico formation, which is most probably of Paleocene age.

The test is almost planispiral to slightly trochoid, comprising about three whorls, with subacute to narrowly rounded margin. The observed diameters range from 0.825 mm. to 1.325 mm., and the thicknesses from 0.3175 mm. to 0.325 mm. The form is slightly bilaterally asymmetrical. The walls of the equitant chambers are rather thick and perforated by radial canals. Toward the dorsal umbonal area, the chamber walls fuse with the walls of the preceding whorl; on the ventral side the alar prolongations of the chambers disappear toward the center, leaving a wide umbilical area filled with shell material perforated by radial canals that are more pronounced than on the dorsal side. On the ventral side, the openings of the canals widen toward the outside and may have produced reticulations on the ventral surface.

Occurrence: Morro del Faro member, Guárico formation, Paleocene. Sample B-1883 comes from the limestone on which the lighthouse of the large morro is built, north of San Juan de Los Morros, State of Guárico. Sample B-5281 was collected from the same stratigraphic unit at the Morro La Gruta, north of San Sebastián, State of Aragua.

Family ORBITOIDIDAE Schubert

Subfamily PSEUDORBITOIDINAE M. G. Rutten

Genus Vaughanina Palmer, 1934

Vaughanina cubensis Palmer
Plate 3, figures 4-8; Plate 4, figures 1, 2

Pseudorbitoides israelskii Vaughan and Cole, 1932 (part), Nat. Acad. Sci., Proc., vol. 18, no. 10, p. 615, pl. 2, fig. 7 (not figs. 1-6).

Vaughanina cubensis Palmer, 1934, Soc. Cubana Hist. Nat., Mem., vol. 8, no. 4, p. 240, pl. 12, fig. 5; pl. 13, figs. 2, 4; text-figs. 2, 3.—Vaughan and Cole, 1943, Jour. Pal., vol. 17, no. 1, pp. 98-100, pl. 17, figs. 3-4; pl. 18, figs. 1-10.—Cole, 1944, Florida, Geol. Survey, Bull., no. 26, p. 57, pl. 3, fig. 11; pl. 21, figs. 6, 7.—Cole and Bermúdez, 1947, Bull. Amer. Pal., vol. 31, no. 125, p. 11, pl. 3, figs. 10-13. —de Cizancourt, 1949, Soc. Géol. France, Bull., ser. 5, vol. 18, fasc. 8-9, p. 670, pl. 24, figs. 1-4.—Bronnimann, 1954, Cushman Found. Foram. Res., Contr., vol. 5, pt. 3, p. 91, pl. 16, figs. 1-11; pl. 17, figs. 1-6; pl. 18, figs. 4-10; text-figs. 1-9.

Vaughanina cubensis Palmer occurs abundantly in the Venezuelan material, but no free specimens were obtained. The identification is based on a large number of vertical sections and on a few incomplete equatorial sections. The species from Cuba has recently been described in great detail by Bronnimann (1954), and very little can be added to his excellent study.

Most of the Venezuelan specimens are of the megalospheric form. They are of small size, with diameters ranging from 0.65 mm. to 2 mm., and thicknesses ranging from 0.4 mm. to 0.67 mm. In vertical sections, the equatorial layer is very well defined and is about 19μ to 25μ high next to the embryonic apparatus, and 50μ to 100μ near the periphery. The shape of the equatorial chambers is rectangular, often convex toward the periphery; they communicate by way of stoloniferous openings that have a diameter of about 5μ. The length of the equatorial chambers, near the embryonic apparatus, is about 12μ to 40μ, and near the periphery, about 25μ to 57μ. In some specimens, the equatorial layer appears to "split" into two or four layers, as seen in figures 5 and 6 of plate 3 and figures 1 and 2 of plate 4. This was also noted by Vaughan and Cole (1943, p. 99). Palmer, on the other hand, observed that the equatorial layer of *Vaughanina* is single throughout, and the correctness of this observation appears to be confirmed by the detailed studies of Bronnimann (1954, pp. 99, 102), who noted that there are no horizontal plates subdividing the equatorial layer, as shown by various centered vertical sections. He further noted that "the number of 'floors' in the peripheral portion of the equatorial layer can be used to estimate the degree of obliquity of a vertical section" and that oblique sections "exhibit the two alternating systems of radial plates, and between the radial plates, two series of large radial stolons." Bronnimann's observations appear to be borne out by the Venezuelan specimens of *Vaughanina cubensis.*

On each side of the equatorial layer, there are about six to eight layers of lateral chambers in the central part of the test, gradually decreasing in numbers toward the periphery, where there is generally one covering the equatorial layer, or at times none at all. The lateral chambers are usually arranged in definite tiers. The length of the lateral chambers from the center of the test to the periphery ranges from 60μ to 120μ, and their height from 20μ to 40μ. The roofs and floors of the lateral chambers are thin, about 5μ to 10μ thick. Pillars are not well developed in the Venezuelan specimens but are suggested, particularly over the central portion of the test, although some of them do not reach the equatorial layer. The surface diameter of the pillars ranges from 38μ to 63μ.

There are only a very few equatorial sections available for study. They clearly show a layer of equatorial chambers that are peripherally replaced by circles of rectangular chamberlets.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Genus Pseudorbitoides H. Douvillé, 1922

Pseudorbitoides israelskii Vaughan and Cole
Plate 4, figures 3-5

Pseudorbitoides israelskii Vaughan and Cole, 1932 (part), Nat. Acad. Sci., Proc., vol. 18, no. 10, p. 614, pl. 2, figs. 1-6 (not fig. 7).—Cushman, 1933, Cushman Lab. Foram. Res., Spec. Publ., no. 4, pl. 38, figs. 5, 7.—M. G. Rutten, 1935, Jour. Pal., vol. 9, no. 6, p. 544, pl. 62, fig. 5; p. 535, text-fig. 4K, L, O, Q.—Vaughan and Cole, 1943, Jour. Pal., vol. 17, no. 1, p. 98, pl. 17, figs. 1, 2.—Cole, 1944, Florida, Geol. Survey, Bull., no. 26, p. 56, pl. 21, figs. 1-5.

A form that is referred to the genus *Pseudorbitoides* is also present among the Venezuelan Maestrichtian material. No free specimens were obtained and the determinations were made from random rock sections, containing some vertical and equatorial sections of megalospheric tests. The Venezuelan form is provisionally referred to *Pseudorbitoides israelskii* Vaughan and Cole, although in the equatorial layer the double chambers near the periphery of the test could not be observed.

The test is small and lenticular. The diameter is, on the average, about 1.2 mm., and the thickness is equal to about half the diameter.

Equatorial sections were poor and the embryonic apparatus could not be observed very well. The embryonic chamber is almost round, with a diameter of about 65μ; the thickness of the wall is about 20μ. The shape of the equatorial chambers is generally polygonal, hexagonal to round. The transverse diameter is 63μ to 82μ, and the radial diameter 38μ to 44μ; the thickness of the walls is from 12μ to 25μ. The round chambers have a diameter of 75μ to 80μ. Between the

equatorial chambers and the periphery there are fine radiating lines, about 5μ to 10μ thick.

In vertical section, the embryonic apparatus can be observed fairly well. It consists of two subspherical chambers, the first somewhat larger than the second. The whole apparatus is 0.25 mm. long and 0.15 mm. wide. The first chamber has a length of 0.15 mm. and a width of 0.15 mm.; the second chamber is 0.1 mm. long and 0.125 mm. wide. The wall of the embryonic apparatus is 12μ to 25μ thick. The opening between the two chambers is about 60μ, but this may be exaggerated by recrystallization. The embryonic apparatus is surrounded by a few indefinite periembryonic chambers. The height of the equatorial layer is about 25μ near the center and about 38μ near the periphery. The double layer of equatorial chambers near the periphery could not be observed, probably because of the state of preservation. There are about ten to twelve layers of lateral chambers on each side of the equatorial layer in the central part; they gradually decrease in numbers toward the periphery of the test, where only two layers can be observed. The lateral chambers are arranged in tiers. In the central part near the periphery, the lateral chambers show a length of about 100μ and a height of about 26μ, with roofs and floors about 5μ to 10μ thick. Between the ends of the lateral chambers there are, particularly in the central part, a number of thick, gradually tapering pillars; their diameter near the periphery ranges between 75μ and 114μ.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816. Also found farther southwest in some Upper Cretaceous limestones, 2.55 kilometers S. 37° E. of the San Juan monument at San Juan de Los Morros, in the headwaters of the Quebrada Aguada (Sample B-5400).

Pseudorbitoides? sp.
Plate 4, figures 6, 7

Two vertical sections of a strongly pillared form may belong to the genus *Pseudorbitoides,* although this cannot be determined with certainty. The two specimens have diameters of 1.28 mm. (fig. 6) and 1.05 mm. (fig. 7), and thicknesses of 0.7 mm. and 0.625 mm., respectively. The equatorial layer, which apparently does not split near the periphery, is 16μ to 18μ high near the embryonic chambers and 25μ to 31μ near the periphery. There are about twelve to fourteen layers of lateral chambers in the central part on each side of the equatorial layer; they are arranged in tiers. The diameter of the pillars in the central umbonal portion ranges from 55μ to 120μ.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Pseudorbitoides? sp.
Plate 4, figure 8

Another fairly good vertical section of a pillared form is figured, but its generic position is very doubtful as there is clearly only one layer of equatorial chambers from the center to the periphery. The specimen has a diameter of 2 mm. and a thickness of 1.1 mm. The embryonic apparatus has a length of 0.25 mm. and a width of about 0.125 mm., and consists of at least two chambers. The equatorial layer is about 25μ high near the center and about 44μ near the periphery. There are about fifteen layers of lateral chambers in the central part, on each side of the equatorial layer. The lateral chambers near the periphery are 80μ to 90μ long and 20μ to 25μ high. Roofs and floors are about 8μ to 10μ thick. At the periphery, the tapering pillars have diameters ranging from 35μ to 125μ.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Subfamily ORBITOIDINAE Prever

Genus OMPHALOCYCLUS Bronn, 1853

Omphalocyclus cf. **macroporus** (Lamarck)
Plate 5, figures 1-10

Orbulites macropora LAMARCK, 1816, *Hist. Nat. Anim. sans Vert.*, vol. 2, p. 197.—FAVRE, 1912, *Catalogue illustré de la collection Lamarck; Polypes fossiles*, pt. 1, pl. 1, figs. 7, 8.

Sporadotrema errantium HOFKER, 1926, Natuurhist. Maandblad, vol. 15, no. 6, pp. 62-65, 20 figs.

Omphalocyclus macropora (Lamarck).—MARCHESINI, 1941, Soc. Toscana Sci. Nat. Pisa, Atti Mem., vol. 49, p. 7, pl. 3, figs. 1-3.

Omphalocyclus sp., M. G. RUTTEN, 1935, Jour. Pal., vol. 9, no. 6, p. 542, pl. 61, fig. 2.—DE CIZANCOURT, 1949, Soc. Géol. France, Bull., ser. 5, vol. 18, fasc. 8-9, p. 670, pl. 24, figs. 5, 8.

Omphalocyclus cf. *macroporus* (Lamarck) is one of the most common forms in the Escorzonera formation of the San Sebastián area. Only one free specimen was available, from which an equatorial section was prepared. The present study is principally based on random rock sections, which contain many vertical sections but very few equatorial sections. Most specimens are badly recrystallized.

The test is biconcave, lenticular and round, with its thinnest part in the center, increasing in thickness

gradually toward the periphery. The diameter of the macrospheric form varies, on an average, from 2 mm. to 3.5 mm., and the microspheric form sometimes attains a diameter up to 7 mm. The embryonic chambers of the microspheric test appear to be planispiral, with the diameter of the embryonic chamber about 75μ. The embryonic apparatus of the megalospheric test is round to slightly elongate, and quadrilocular; it has a diameter of 0.25 mm. to 0.3 mm., and consists of four chambers, each with a diameter of 0.1 mm. to 0.175 mm. The wall surrounding the embryonic apparatus shows very fine perforations and has a thickness of 20μ to 30μ.

In equatorial section, the embryonic apparatus is surrounded by irregularly shaped lateral chambers, with their convex sides toward the periphery. The height of these chambers, near the embryonic apparatus, is about 35μ to 50μ and their width 60μ to 90μ. They increase in size toward the periphery, and at 0.3 mm. from the embryonic chambers, they are about 50μ to 65μ high and 90μ to 100μ wide. The lateral chambers intercommunicate by stoloniferous openings, about 12μ to 15μ wide. The medium layer is composed of wavy concentric rings of chambers about 100μ to 120μ high, largely filled with calcite.

In vertical section, the specimens are usually surrounded by a calcite layer up to 60μ thick. In the central part of the test, there is, on each side of the proloculum, a single layer of chambers, about 0.13 mm. wide and about 30μ high. As growth progresses, this single layer becomes double, and some distance from the proloculum a median layer is intercalated. In most specimens, however, it cannot be differentiated from the lateral chambers. In one specimen, the median layer of chambers is quite distinct from the lateral chambers (pl. 5, fig. 3).

The lateral chambers on each side of the median layer are about 90μ wide and 30μ high near the proloculum, and 215μ wide and 90μ high near the periphery. The lateral chambers intercommunicate by stoloniferous openings that have a diameter of 25μ to 40μ.

About 0.5 mm. from the proloculum, the median chambers are about 120μ wide and 60μ high; near the periphery, they show a width of 0.25 mm. and a height of 0.165 mm. The median chambers intercommunicate by means of stolons, and they communicate with the lateral chambers by means of large openings in the floors of the lateral chambers.

The specimens figured by de Cizancourt (1949) are in every respect identical with the forms described here; they were also collected from the Escorzonera formation of the San Sebastián region.

The Venezuelan form of *O.* cf. *macroporus* (Lamarck) appears to be identical with the species figured by M. G. Rutten from the Upper Cretaceous of Cuba. For comparison, we show here a few specimens from the Habana formation of Cuba (pl. 5, figs. 4, 10), which were kindly supplied by Dr. Pedro Bermúdez. A specimen from Maestricht, Netherlands, is also figured (pl. 5, figs. 7-9), which was also received through the courtesy of Dr. Bermúdez.

Because of the lack of authentic comparative material of *Omphalocyclus macroporus* (Lamarck), we refer our specimens only tentatively to this species, which has a widespread distribution in the Maestrichtian of Europe and India.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Samples B-4816, B-6443.

Genus Orbitoides d'Orbigny, 1848

Orbitoides palmeri Gravell
Plate 6, figures 1-3

Orbitoides palmeri Gravell, 1930, Jour. Pal., vol. 4, no. 3, p. 269, pl. 22, figs. 1-10.—Cole, 1944, Florida, Geol. Survey, Bull., no. 26, p. 55, pl. 21, fig. 13.

Orbitoides palmeri Gravell, which was originally described from the Upper Cretaceous of Cuba and later recorded by Cole from the Upper Cretaceous of Florida, is also present in the upper part of the Escorzonera formation of the San Sebastián area, State of Aragua, Venezuela. The form is comparatively rare and is associated with abundant *Sulcoperculina dickersoni* (Palmer) and *S. globosa* de Cizancourt, as well as *Vaughanina cubensis* Palmer. In Cuba and Florida the species appears to occur in a similar association. Among the Venezuelan material it is represented by several vertical sections and one equatorial section through the embryonic apparatus of a megalospheric form.

The diameter of the Venezuelan specimens varies between 1.65 mm. and 2.4 mm., and the thickness between 0.75 mm. and 0.825 mm. There is in our material an excellent equatorial section through the embryonic apparatus, which is ellipsoidal and quadrilocular. The apparatus is surrounded by a thick wall with perforations 5μ to 6μ in diameter; the thickness of the wall along the long axis is about 32μ to 38μ, and along the short axis 50μ to 63μ. The length of the embryonic apparatus is 0.508 mm. and the width 0.381 mm.

The four chamberlets embraced in the embryonic apparatus are of various shapes and sizes. The two chamberlets at each end of the long axis are round to elongate, about 0.19 mm. to 0.2 mm. high and 0.127 mm. to 0.133 mm. wide; their wall adjacent to the other chamberlets is about 7μ to 12μ thick. Along the main wall of the embryonic apparatus there is an opening about 6μ wide, which communicates with the other chamberlets. Along the short axis of the apparatus there are two chamberlets of unequal size; the larger one is trapezoidal, about 0.25 mm. wide at the base and about 0.13 mm. wide at the top, with a height of 0.16 mm. The small chamberlet is rectangular, about 0.14 mm. wide and 0.1 mm. high. A very thin wall, about 5μ thick, separates these two chamberlets. The equatorial chambers directly bordering the embryonic apparatus are 63μ to 75μ wide and 44μ to 63μ high.

In vertical sections, the layer of equatorial chambers is about 0.10 mm. to 0.127 mm. thick near the center, and 0.18 mm. to 0.2 mm. thick near the periphery. The loosely knit equatorial chambers intercommunicate on their proximal sides by one, or sometimes by two, large stoloniferous apertures, about 19μ in diameter (pl. 6, fig. 2). The wall of this aperture is about 5μ thick. There are about ten to twelve layers of lateral chambers on each side of the equatorial layer, often obscured by strong and irregularly thickened pillars. The lateral chambers are low and arched, and not arranged in definite tiers.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Subfamily LEPIDOCYCLININAE Tan

Genus Lepidorbitoides Silvestri, 1907

Lepidorbitoides? sp.
Plate 6, figures 7, 8

The Venezuelan material contains a few interesting but unfortunately undeterminable forms that show in vertical section a rather characteristic outline; they are provisionally referred to the genus *Lepidorbitoides*. No equatorial sections are available for study.

The test is small, strongly biconvex, almost quadrate, with the sides sloping regularly from the center to the periphery. The diameters of the two forms are 1.25 mm. and 1.3 mm., and their thicknesses 0.95 mm. and 0.65 mm., respectively. The equatorial layer is about 20μ thick near the center and thickens gradually to 32μ at the periphery. The embryonic apparatus is recrystallized to such an extent that no reliable measurements can be made, but it seems to consist of a larger and a smaller chamber. On both sides of the equatorial layer, there appear to be, in the central part, about ten to twelve layers of lateral chambers, which are arranged in tiers. The number of lateral chambers decreases toward the periphery, where there are only one or two layers covering the equatorial layer. The form has a few indistinct pillars in the central part of the test. *Lepidorbitoides?* sp. is, in some ways, related to *Lepidorbitoides (L.) floridanus* Cole (1942, p. 37, pl. 9, figs. 5, 6) from the Upper Cretaceous of Florida. However, the quadrate outline in vertical section is much more pronounced in the Venezuelan form, and the strong pillar on either side of the equatorial layer, at the center, is absent.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Lepidorbitoides? sp.
Plate 6, figures 4-6

A few vertical sections and one very unsatisfactory equatorial section of a form that is questionably referred to the genus *Lepidorbitoides* are figured. It is associated with other typically Maestrichtian larger foraminifera.

The form is small and lenticular with a diameter ranging from 0.85 mm. to 1.35 mm. The thickness varies between 0.425 mm. and 0.6 mm. The well-defined equatorial layer is 19μ thick near the center and 25μ to 31μ at the periphery. The length of the equatorial chamberlets near the center ranges from 25μ to 31μ and at the periphery between 31μ and 50μ. There are usually nine, occasionally as few as seven layers of lateral chambers on either side of the equatorial layer; they are arranged in definite tiers. The length of the lateral chambers near the center is 30μ to 50μ, and the height 10μ to 20μ; near the periphery the lateral chambers are 50μ to 75μ long and 20μ to 32μ high. The floors and roofs are very thin, and measure about 5μ. Pillars are essentially absent, but it can be observed that the distal ends of the lateral chambers sometimes thicken, and a faint impression of pillars is created. In equatorial section, the chamberlets have diameters ranging from 32μ to 57μ.

Occurrence: Upper Cretaceous (Maestrichtian), headwaters of Quebrada Aguada, 2.55 kilometers S. 37° E. of the San Juan monument at San Juan de Los Morros, State of Guárico. Sample B-5400.

Subgenus ASTERORBIS Vaughan and Cole, 1932

Lepidorbitoides (Asterorbis) cubensis (Palmer)
Plate 7, figures 2, 4, 8

Asterorbis? cubensis PALMER, 1934, Soc. Cubana Hist. Nat., Mem., vol. 8, no. 4, p. 249, pl. 13, figs. 6, 9, 10; pl. 14, fig. 9.

Lepidorbitoides (Cryptasterorbis) cubensis (Palmer).—M. G. RUTTEN, 1935, Jour. Pal., vol. 9, no. 6, p. 536, pl. 60, fig. 5; pl. 61, figs. 3, 8, 9; text-fig. 4A, B, I, J.

The subgenus *Lepidorbitoides (Asterorbis)* is very well represented in the Venezuelan material, but *Lepidorbitoides (Asterorbis) cubensis* is less common than the related *Lepidorbitoides (Asterorbis) havanensis* (Palmer), from which it can be distinguished by its great thickness. Sometimes it is almost spherical, and in vertical section has many more layers of lateral chambers on either side of the equatorial layer than *L. (A.) havanensis.*

The Venezuelan specimens that are referred to this species are very small; the diameter varies from 1.325 mm. to 2.125 mm., and the thickness varies from 1.125 mm. to 1.85 mm. The circumference is almost round, occasionally with four or five short arms.

No satisfactory equatorial section was obtained, but the rayed structure shows distinctly in the arrangement of the equatorial chambers. The embryonic apparatus is very indistinct and is ellipsoidal, with a length of 0.2 mm. and a width of 0.15 mm. Because of recrystallization, no chambers can be distinguished within the embryonic apparatus. The equatorial chambers have curved outer walls and are arranged in concentric layers as in *L. (A.) havanensis.*

The vertical sections are spherical. The equatorial layer increases slowly in height from the center toward the periphery. It is about 25μ high near the center and about 38μ high near the periphery. Sections through one of the arms show that the equatorial layer thickens and becomes bulb-like near the periphery, where it may be as high as 115μ. The lateral chambers are low and arranged in definite tiers. In the central umbonal part, there are about twenty to thirty layers, but this number decreases rapidly toward the periphery, where there may be only one layer on each side of the equatorial layer. The tiers of lateral chambers widen gradually from the center toward the umbo. The chamber cavities near the center are about 60μ long and 18μ high; in the umbonal part they are 90μ long and 25μ high. Pillars are quite frequent and well-developed; they are formed by the thickening of the chamber roofs, and most of them do not reach the equatorial layer. They measure about 50μ to 100μ in diameter in the umbonal part.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua, Venezuela. Samples B-6444, B-4816.

Lepidorbitoides (Asterorbis) havanensis (Palmer)
Plate 7, figures 1, 3, 5-7; Plate 8, figures 1-3, 5

Asterorbis? havanensis PALMER, 1934, Soc. Cubana Hist. Nat., Mem., vol. 8, no. 4, pp. 251-252, pl. 13, fig. 11; text-figs. 13, 14.

Lepidorbitoides (Asterorbis) havanensis (Palmer) is very common in the Escorzonera formation of Venezuela. A few free specimens were obtained. An external view of one of them is shown in pl. 7, fig. 5.

The test of the Venezuelan specimens is very small, with average diameters ranging from 1.95 mm. to 2.5 mm., but one microspheric test measures 3.25 mm. The thickness ranges from 0.8 mm. to 1.25 mm. The test is lenticular, stellate, with four blunt points. The surface of worn specimens shows the reticulation of the lateral chambers, and the center is covered with a number of papillae formed by the projecting ends of the pillars.

The embryonic apparatus, which is poorly preserved, is ellipsoidal and measures about 0.214 mm. by 0.15 mm. It is surrounded by a thick wall, about 18μ thick. The nucleoconch is bilocular; the first chamber is subspherical, and measures 107μ by 113μ. The second chamber is somewhat larger, 107μ by 150μ, slightly reniform, and shows a tendency partially to embrace the first chamber. The embryonic apparatus is surrounded by obscure periembryonic chambers with an indefinite arrangement.

In equatorial section there are always four arms, and the rayed structure of the test is clearly seen in the equatorial layer. The equatorial chambers are low and diamond-shaped, or their outer walls are curved and the inner ends pointed or truncate. Because of recrystallization the form of the chambers is not always easy to determine. As in *Orbitocyclina,* the equatorial chambers are arranged in concentric layers that parallel the periphery and are most clearly visible over the four arms. The equatorial chambers near the nucleoconch measure 31μ in radial diameter and 44μ in transverse diameter; near the periphery they measure about 100μ by 63μ.

In vertical section, the layer of equatorial chambers increases slowly in height from the center to the periphery. Near the center the chambers are 25μ to 31μ high; along the arms, near the periphery, they are 44μ to 57μ high. In a few sections the equatorial layer thickens and becomes bulb-like near the periphery, and may be 190μ to 250μ thick. The lateral chambers

on either side of the equatorial layer are arranged in tiers; in the central umbonal part there are about sixteen to eighteen layers, which decrease gradually in number toward the periphery, and at the peripheral edge there may be only one or two. In some specimens the equatorial layer is not covered by lateral chambers. Near the central part the cavities of the lateral chambers are about 65μ long and 19μ high. The roofs of the chambers are about 10μ to 12μ thick. Pillars are few but well developed; they are formed by thickening of the chamber roofs and usually do not reach the equatorial layer. Their thickness in the umbonal part of the test reaches 75μ to 170μ.

In comparison with the Cuban form of *L. (Asterorbis) havanensis* (Palmer) that is figured in pl. 8, figs. 3, 5, the Venezuelan form has fewer layers and somewhat larger lateral chambers.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua, Venezuela. Samples B-6444, B-6451, B-4816.

Lepidorbitoides (Asterorbis) sp.
Plate 6, figure 9

As a matter of record, a vertical section of a specimen that cannot be precisely determined is figured. It is a strongly pillared form, about 2.55 mm. in diameter and 1.4 mm. in thickness. The embryonic apparatus has a length of 0.24 mm. and a width of 0.17 mm. The equatorial layer is about 25μ high near the center and 60μ high near the periphery. On either side of the equatorial layer, there are about eighteen to twenty layers of lateral chambers in the umbonal part. The four strong pillars in the central portion have a diameter of 0.18 mm. to 0.25 mm.

Occurrence: Escorzonera formation (Maestrichtian), Arrayanes group. Paso Copey, west of San Sebastián, State of Aragua. Sample B-4816.

Genus Actinosiphon Vaughan, 1929

Actinosiphon barbadensis (Vaughan)

Lepidorbitoides cf. *planasi* Rutten.—Caudri, 1944, Bull. Amer. Pal., vol. 28, no. 114, p. 366, pl. 1, fig. 3; pl. 2, fig. 10; pl. 3, fig. 14; 1948, Jour. Pal., vol. 22, no. 4, pp. 473-481.
Lepidocyclina (Polylepidina) barbadensis Vaughan, 1945, Geol. Soc. Amer., Mem., no. 9, p. 49, pl. 19, figs. 5-9.

Actinosiphon barbadensis (Vaughan)
forma **caudriae** de Cizancourt
Plate 8, figures 4, 6, 7

Actinosiphon barbadensis (Vaughan) forma *caudriae* de Cizancourt, 1951, Soc. Géol. France, Mém., new ser., vol. 30, fasc. 1-2, no. 64, p. 58, pl. 5, figs. 5, 7.

A few specimens of this interesting form are figured. They were collected from the Morro del Faro member of the Guárico formation (Sample B-5537) in the vertical walls of the great morros of San Juan, State of Guárico, and from the topmost part of the Vidoño formation (Sample B-5006), Río Pao, west of San Sebastián, State of Aragua. Both localities are generally considered to be Paleocene.

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PLATE 1

Figure 1 *Quinqueloculina* sp.

Sample B-5086: Paleocene, Guárico formation, San Juan de Los Morros member; El Pao, west of San Sebastián, State of Aragua. Transverse section, × 90.

2 *Nummulites tobleri* (Vaughan and Cole)

Sample B-5537: Paleocene, Guárico formation, Morro del Faro member; southeast corner of the large morros of San Juan, State of Guárico. Vertical section, × 30.

3-8 *Sulcoperculina globosa* de Cizancourt

Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 3, vertical section, × 62, Sample B-6444; 4, vertical section, × 44, Sample B-6444; 5, vertical section, × 50, Sample B-4816; 6, vertical section, × 60, Sample B-6451; 7, equatorial section, × 50, Sample B-6444; 8, equatorial section, × 43.5, Sample B-6444.

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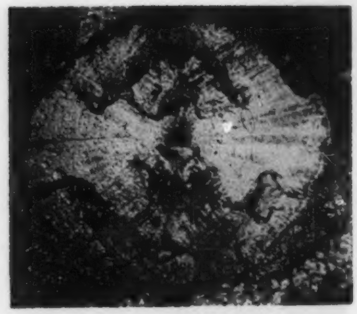

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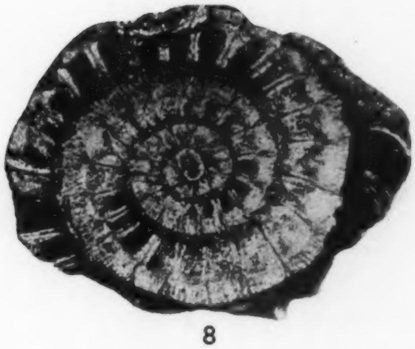

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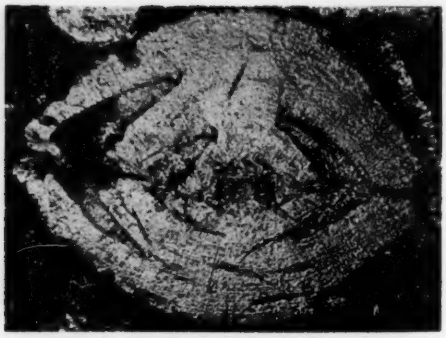

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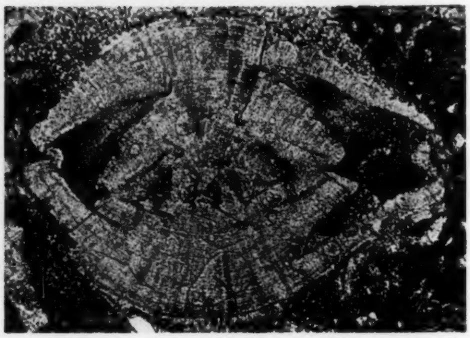

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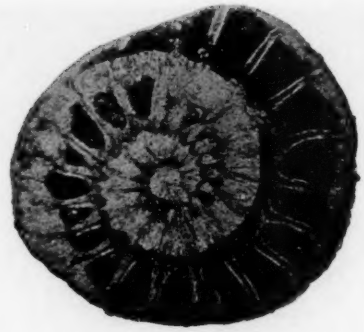

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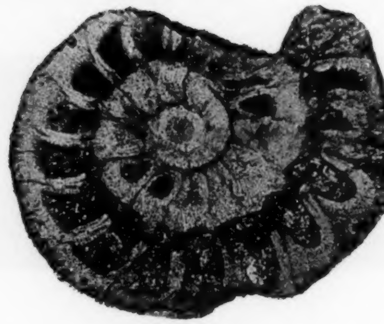

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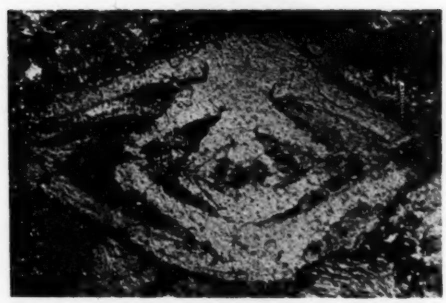

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PLATE 2

Figures 1-2 *Sulcoperculina obesa* de Cizancourt

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Vertical sections: 1, × 58; 2, × 69.

3-7 *Sulcoperculina dickersoni* (Palmer) var. *vermunti* (Thiadens)

Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 3, vertical section, × 51, Sample B-6444; 4, vertical section, × 46, Sample B-6444; 5, equatorial section, × 50, Sample B-6444; 6, equatorial section, × 73, Sample B-6444; 7, vertical section, × 58, Sample B-4816.

8 *Sulcoperculina dickersoni* (Palmer) var. *vermunti* (Thiadens)

Bermúdez Station 537: Kilometer 10, Pinar del Río — Luis Lazo road, Pinar del Río Province, Cuba. Equatorial section, × 53.

PLATE 3

Figure 1 *Sulcoperculina dickersoni* (Palmer) var. *vermunti* (Thiadens)

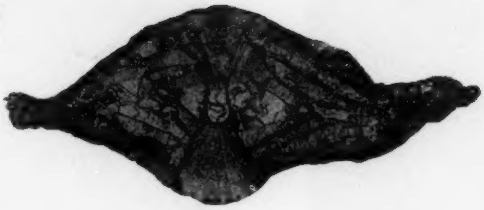
Bermúdez Station 537: Kilometer 10, Pinar del Río — Luis Lazo road, Pinar del Río Province, Cuba. Vertical section, × 40.

2-3 *Laffitteina* sp.

Paleocene, Guárico formation, Morro del Faro member. 2, vertical section, × 87, Sample B-1883: at base of lighthouse, large morro of San Juan, State of Guárico; 3, vertical section, × 58, Sample B-5281: at Morro de la Gruta, north of San Sebastián, State of Aragua.

4-8 *Vaughanina cubensis* Palmer

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 4, vertical section, × 46; 5, oblique vertical section, × 70; 6, vertical section, × 90; 7, vertical section, × 75; 8, oblique equatorial section, × 70.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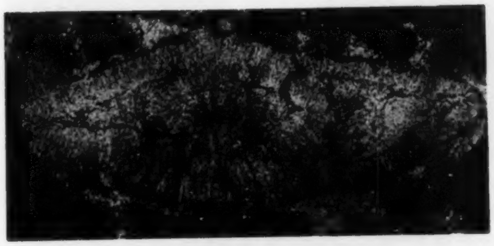
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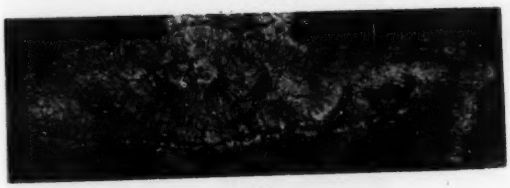
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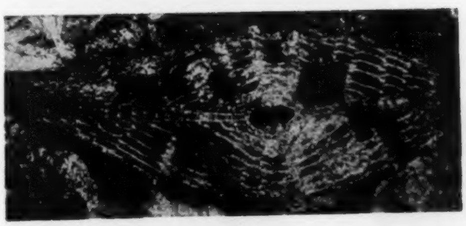
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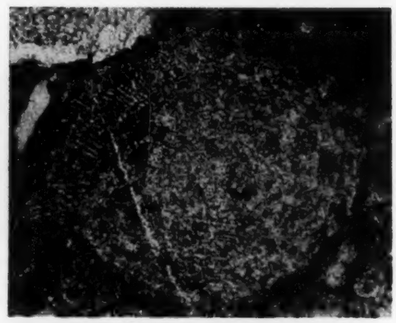
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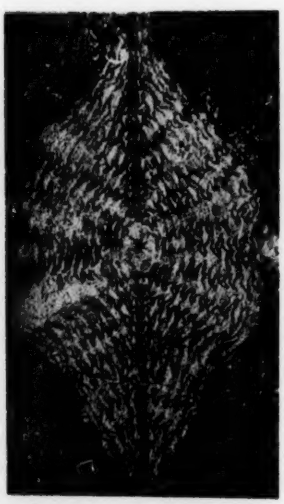
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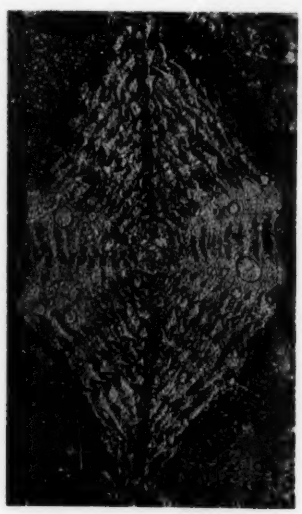
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PLATE 4

Figures 1-2 *Vaughanina cubensis* Palmer

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Oblique vertical sections: 1, × 90; 2, × 66.

3, 5 *Pseudorbitoides israelskii* Vaughan and Cole

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 3, vertical section, × 46; 5, oblique equatorial section, × 50.

4 *Pseudorbitoides israelskii* Vaughan and Cole

Sample B-5400: Upper Cretaceous, Maestrichtian; 2.55 km. S. 37° E. of the San Juan monument at San Juan de Los Morros, in the headwaters of Quebrada Aguada. Oblique equatorial section, × 70.

6-7 *Pseudorbitoides?* sp.

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Vertical sections: 6, × 57; 7, × 70.

8 *Pseudorbitoides?* sp.

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Vertical section, × 37.

PLATE 5

Figures 1-3, 6 *Omphalocyclus* cf. *macroporus* (Lamarck)

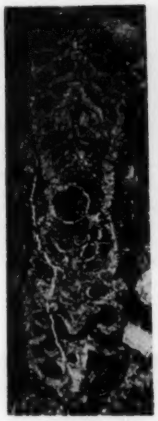
Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 1, vertical section, × 23, Sample B-4816; 2, equatorial section, × 22, Sample B-4816; 3, vertical section, × 50, Sample B-4816; 6, equatorial section, × 50, Sample B-6443.

4-5, 10 *Omphalocyclus* cf. *macroporus* (Lamarck)

Bermúdez Station 26: Upper Cretaceous, Habana formation; Cuba. 4, vertical section, × 20; 5, equatorial section, × 12.5; 10, external view, × 12.5.

7-9 *Omphalocyclus* cf. *macroporus* (Lamarck)

Upper Cretaceous, Maestrichtian, at Maestricht, Netherlands. 7, lateral view, × ca. 8.5; 8, external view, × ca. 8.5; 9, equatorial section, × 10.5.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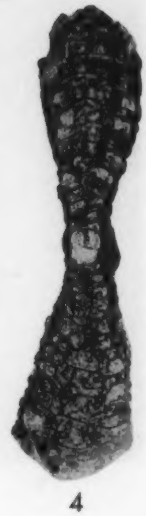
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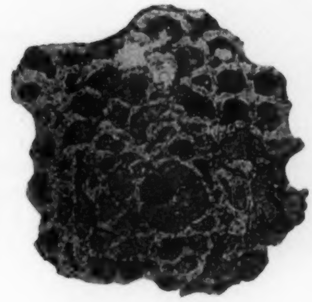
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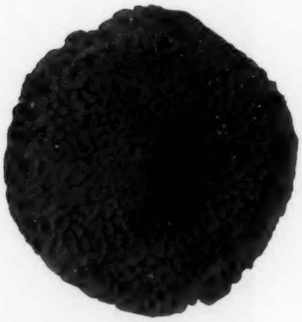
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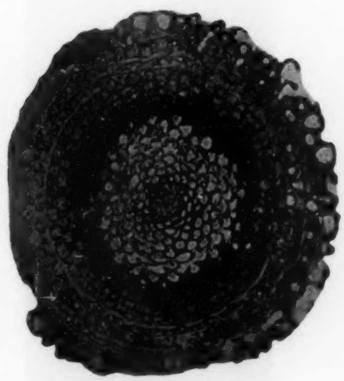
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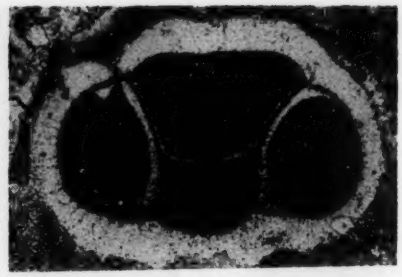

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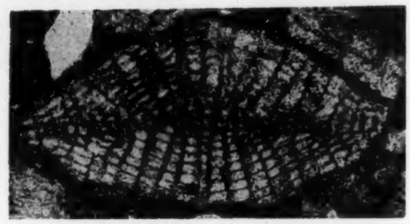

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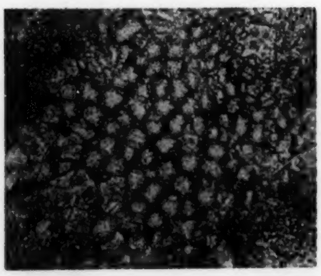

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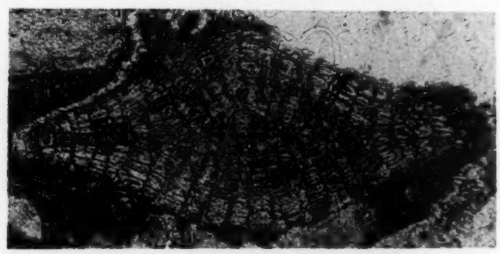

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PLATE 6

Figures 1-3 *Orbitoides palmeri* Gravell

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 1, vertical section, × 31; 2, part of vertical section enlarged, × 176, showing the loosely knit equatorial chambers and the large stoloniferous apertures; 3, equatorial section through the embryonic apparatus, × 110.

4-6 *Lepidorbitoides?* sp.

Sample B-5400: Upper Cretaceous, Maestrichtian, 2.55 km. S. 37° E. of the San Juan monument at San Juan de Los Morros, in the headwaters of Quebrada Aguada. 4, 6, vertical sections; 5, oblique equatorial section. All × 53.

7-8 *Lepidorbitoides?* sp.

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Vertical sections: 7, × 46; 8, × 50.

9 *Lepidorbitoides (Asterorbis)* sp.

Sample B-4816: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. Vertical section, × 27.

PLATE 7

Figures 1, 3, 5-7 *Lepidorbitoides (Asterorbis) havanensis* (Palmer)

Sample B-6444: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 1, vertical section, × 32; 3, vertical section, × 34; 5, external view, × 21; 6, equatorial section, × 17; 7, equatorial section, × 30.

2, 4, 8 *Lepidorbitoides (Asterorbis) cubensis* (Palmer)

Sample B-6444: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 2, vertical section, × 27; 4, equatorial section, × 25; 8, vertical section, × 43.


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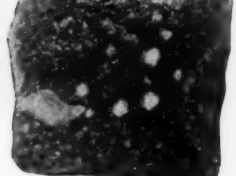
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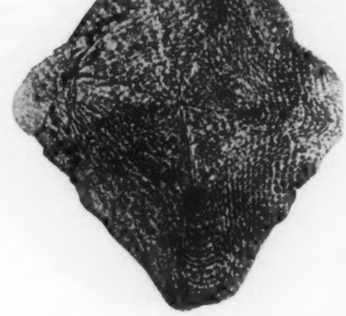
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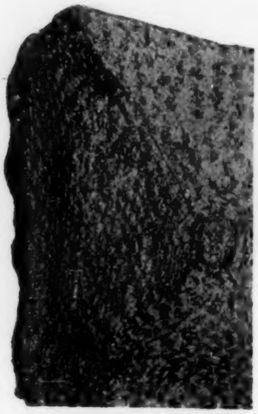

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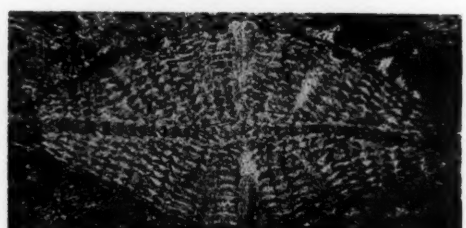

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PLATE 8

Figures 1-2 *Lepidorbitoides (Asterorbis) havanensis* (Palmer)

Sample B-6444: Upper Cretaceous, Maestrichtian, Arrayanes group, Escorzonera formation; Paso Copey, west of San Sebastián, State of Aragua. 1, equatorial section, same as pl. 7, fig. 6, enlarged, × 30; 2, equatorial section, × 43.

3, 5 *Lepidorbitoides (Asterorbis) havanensis* (Palmer)

Upper Cretaceous, Habana formation; El Silencio quarry, Esperanza — Santa Clara road, Santa Clara Province, Cuba. 3, vertical section, × 30; 5, equatorial section, × 30.

4 *Actinosiphon barbadensis* (Vaughan) forma *caudriae* de Cizancourt

Sample B-5006: Paleocene, topmost part of the Vidoño formation; Río Pao, west of San Sebastián, State of Aragua. Equatorial section, × 60.

6-7 *Actinosiphon barbadensis* (Vaughan) forma *caudriae* de Cizancourt

Sample B-5537: Paleocene, Guárico formation, Morro del Faro member; southeast corner of the large morros of San Juan, State of Guárico. 6, oblique section, × 38; 7, vertical section, × 50.

ABSTRACT: *Correlation of the Tertiary of the Far East and Europe is possible only for the Stampian (Tertiary* d*), Sannoisian (Tertiary* c*), and probably the Priabonian (Tertiary* b*). Correlation between Tertiary* e *and* f *and the Chattian — Aquitanian — Burdigalian (or Vindobonian) is at present not feasible.*

Correlation of the Tertiary of the Far East and Europe

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One of the most discouraging tasks of a geologist is the reading of papers on systematic palaeontology. Again and again he is disappointed in his hopes of obtaining from that quarter the means of solving his stratigraphic problems. The cause of his disappointment is the extreme disagreement in viewpoint among different palaeontologists. When the geologist believes he has found an index species that will enable him to make a particular correlation, his hopes are often dashed when he observes that there is considerable divergence of opinion among palaeontologists with regard to the evaluation of specific characters. He is then reminded of the old quarrel between "splitters" and "lumpers." It is somewhat disconcerting to observe, for example, that Berry (1929) splits the Lepidocyclinas of the Verdun formation of northwestern Peru into seventy species, all of them "new," whereas Grimsdale (1952), in describing the Lepidocyclinas of the Oligocene of Iraq, lumps twenty-five "species" together under the name *Lepidocyclina ephippioides* (Jones and Chapman).

Statistical methods are often used, in order to eliminate the personal factor. Here also, however, difficulties may arise. Quite often the material is too scanty to permit the use of these methods. Even if this is not the case, many palaeontologists are deterred by the laborious nature of the process. Moreover, they know that the fossils collected from a particular locality do not, as a rule, reflect the population that once lived at that spot. In other words, the palaeontologist must nearly always deal with a thanatocoenose rather than with a biocoenose.

The geologist will probably be somewhat more hopeful when he reads the publications of those palaeontologists whose work is concerned with evolution. One of the most striking examples of this is the principle of nepionic acceleration, as it has been established in the foraminiferal genera *Cycloclypeus and Miogypsina* (van der Vlerk, 1923; Tan, 1932; Drooger, 1952). This principle states that, during the development of the family, the nepionic stage is passed through with increasing rapidity in the course of time. Here too, however, the final solution to the problems of the stratigrapher is not found. The difficulty is that in one region evolution may have been more rapid than in another, so that morphologically identical populations in different areas are not necessarily synchronous.

I am of the opinion that the way out of this impasse is to use only those fossils whose identity is not in dispute. Table 1 gives a list of such fossils in the Tertiary of the Far East. It contains seventeen genera, twelve subgenera, and three species, and is an extension of a similar list published previously (van der Vlerk and Umbgrove, 1927). At that time, only fourteen genera were listed. The fact that, after twenty-seven years of intensive stratigraphic work, the vertical distribution of these genera has hardly changed demonstrates the soundness of this method. The extension of the list is a result, first, of the fact that the genera *Lepidocyclina* and *Cycloclypeus* have been split into subgenera, and, secondly, of the discovery of new genera *(Halkyardia, Miscellanea, Ranikothalia)* during a re-examination of the collection of thin sections in the Micropalaeontological Laboratory at Leiden (Zijlmans, MS.). Of the three species listed in Table 1, two *(Heterostegina borneensis* and *Nephrolepidina isolepidinoides)* are described as typical transition forms between two genera or subgenera (van der Vlerk, 1929). The third species, *Nummulites fichteli,* is one of the rare nummulites concerning whose identification there is remarkable unanimity among palaeontologists. It is one of the typical Oligocene nummulites, in which, according to Grimsdale (1952, p. 237, footnote), "the septa in median section tend to be approximately radial for

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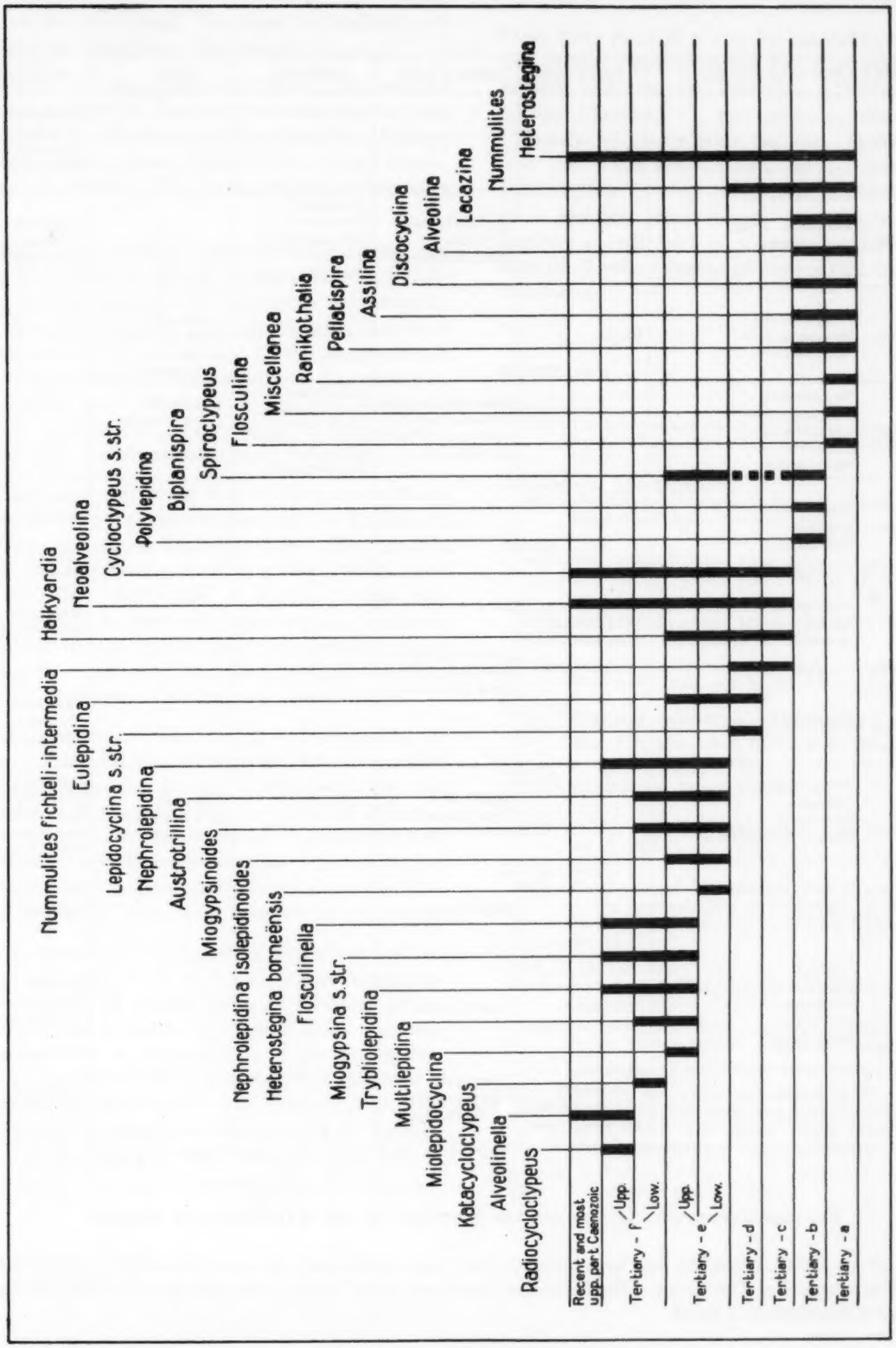
micropaleontology, vol. 1, no. 1, pp. 72-75, tables 1-2, january, 1955

TABLE 1



STRATIGRAPHIC DISTRIBUTION OF FORAMINIFERA IN THE TERTIARY OF THE FAR EAST

TABLE 2

INDONESIA AND NEW GUINEA	PAKISTAN	MIDDLE EAST	MOROCCO	SICILY	AQUITAINE
	(Gaj)				Burdigalian (Drooger) (Miolepidocyclina and Miogypsina s.str.)
Tertiary-f Upp.: Miogypsina s.str. Nephrolepidina		Upp. Qum-formation of Persia (same association)	„Burdigalian" (Brönnimann) (same association but with Miolepidocyclina)		Aquitanian (Drooger) (same association)
Tertiary-f Low.: Miogypsinoides Miogypsina s.str. Nephrolepidina		Middle Qum-formation of Persia (same association but without Miolepidocyclina)		„Burdigalian" (same association but with Miolepidocyclina)	?
Tertiary-e Upp.: Miogypsinoides Miolepidocyclina Miogypsina s.str. Eulepidina Nephrolepidina			„Aquitanian" and „Chattian" (Brönnimann) (same association but without Miolepidocyclina)	„Aquitanian" (same association but with Miolepidocyclina)	?
Tertiary-e Low.: Miogypsinoides Eulepidina Nephrolepidina					Chattian (Cuvillier and Drooger) (same association)
Tertiary-d: Lepidocyclina s.str. or/and Eulepidina Nummulites fichteli-intermedia	Upp. Nari (W.L.F. Nuttall) (same association)	„Lower Oligocene" (Grimsdale) (Same associations)			Stampian (same association)
Tertiary-c: Nummulites fichteli-intermedia	(Low. Nari)				Sannoisian (Cuvillier) (same association)
Tertiary-b: Discocyclina Pellatispira Biplanispira (elsewhere: Chapmanina)	(Kirthar)	„Upp. Eocene" (Same association but with Chapmanina)		Priabonian (same association but with Chapmanina)	Priabonian (Cuvillier) (without Pellatispira and Biplanispira but with Chapmanina)
Tertiary-a: Flosculina Discocyclina Pellatispira Miscellanea Ranikothalia		„Middle Eocene"			Lutetian
	Laki (L.M. Davies) (with Flosculina)	„Lower Eocene"			Ypresian (Cuvillier) (with Flosculina)
	Upp. Ranikot (L.M. Davies) (with Miscellanea and Ranikothalia)	„Paleocene" (with Miscellanea and Ranikothalia)			Landenian Montian

FORAMINIFERAL ASSOCIATIONS IN THE TERTIARY OF THE FAR EAST AND EUROPE

Where no author's name is given, the data have been obtained from unpublished reports in the archives of the "Bataafsche Petroleum Maatschappij" at The Hague. The indication "same association" refers to the associations of the Far East upon which the letter-classification is based.

the inner one-half to two-thirds of their length, being sharply reflexed in the outer portion." In the Eocene forms, on the other hand, "the septa are inclined and gently curved throughout their length."

Of the thirty-two foraminifera in Table 1, thirteen are also listed in Table 2. They are the forms that are also important in the subdivision of the Tertiary of Europe and some adjacent areas. Table 2 (see, among others, Davies, 1940; Nuttall, 1925) demonstrates the following points:

(a) There is a striking resemblance between the faunas of Tertiary *c* and *d* of Indonesia and New Guinea, and the faunas of the Sannoisian and Stampian of Europe and elsewhere. The older epoch (Tertiary *c* and Sannoisian) is characterized by the occurrence of *Nummulites fichteli-intermedia,* without *Eulepidina* or *Lepidocyclina* s.str. Tertiary *d* and the Stampian, however, contain the same species of *Nummulites* together with the above-mentioned subgenera.

(b) There is a somewhat less striking resemblance between Tertiary *b* of the Far East and the Priabonian of Europe. The genus *Biplanispira* is a characteristic fossil in the Far East as well as in the Middle East (van der Vlerk, MS.) and in Sicily (Lagaaj and Wagner, MS.). In both of these regions, however, *Biplanispira* is accompanied by *Chapmanina,* a genus that may be considered an index fossil of the Priabonian of Aquitaine (Cuvillier and Sacal, 1951).

(c) Of three foraminifera that are characteristic of Tertiary *a* in the Far East *(Flosculina, Miscellanea* and *Ranokothalia),* the first is found in the Laki series and the other two in the upper Ranikot series of Pakistan. Moreover, *Miscellanea* and *Ranokothalia* are mentioned by Grimsdale (1952) from what he calls the "Paleocene" of the Middle East, and *Flosculina* by Cuvillier and Sacal (1951) from the Ypresian of Aquitaine.

(d) A comparison of the faunas of Tertiary *e* and *f* of the Far East with those of the Chattian, Aquitanian and Burdigalian of Europe gives an inversion of the presumed zonal sequence. Drooger (1954) mentions *Miolepidocyclina* as characteristic of the Burdigalian of Europe. In the Far East, however, this subgenus is found in the probably much older Tertiary *e.* In addition, although the Miogypsinidae survived the Lepidocyclinae in Europe, the same does not hold true in the Far East. One must, however, consider the possibility that this discrepancy is a result of special facies conditions.

From these remarks it may be concluded that correlation of the Tertiary of the Far East and Europe is possible only for the Stampian (Tertiary *d*), Sannoisian (Tertiary *c*), and probably the Priabonian (Tertiary *b*). Correlation between Tertiary *e* and *f* and the Chattian — Aquitanian — Burdigalian (or Vindobonian) is at present quite impossible. Finally, it is probable that further stratigraphic study of Tertiary *a* will lead to a more precise comparison with the Tertiary epochs of Europe that are older than Priabonian.

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ABSTRACT: *A confirmation of Jeletsky's and Wicher's theories of a warm-water phase in the Baltic area toward the end of Maestrichtian time is found in the fact that the southern species* Globotruncana contusa *(Cushman) occurs in a marl layer in the uppermost part of the White Chalk. The restriction of the presumably planktonic* Globotruncana contusa *to a certain lithofacies is tentatively explained. The Kjölby Gaard marl is formally defined.*

Globotruncana contusa in the White Chalk of Denmark

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INTRODUCTION

The Upper Cretaceous "Chalk" or "White Chalk" (a formation name, not a purely lithologic term) of northwestern Denmark is ordinarily snow-white, with bands and nodules of black chert offering the only variation. The infrequently-occurring marly layers therefore attract more attention than they would in a limestone formation of a darker color. The incentive to write the following note came from the discovery that the most prominent of the marl layers contains an unusual microfauna.

Thanks are due to Dr. Maria Bianca Cita, Milan, for valuable information. Miss Ruth Todd and Dr. Alfred R. Loeblich, Washington, D. C., helped by permitting the writer to examine type specimens in their care. Miss Gunni Jörgensen made the drawings of *Globotruncana.* The Danish Science Foundation (Statens Almindelige Videnskabsfond) helped to defray the cost of a visit to some museums in the United States.

SECTION AT KJÖLBY GAARD

In an abandoned shore-line cliff at Kjölby Gaard in Tisted County, northwestern Denmark, the following section may be seen (Ödum, 1926, pp. 95-96, 196-197; Troelsen, 1937, figs. 2-3):

	Thicknesses in meters
A. Lower Danian	
1. White coccolithic limestone	ca. 1.25
2. Light gray clay or marl, passing upward into the overlying limestone, downward with a very distinct contact	ca. 0.09
B. Simple erosional disconformity separating the lower Danian and the upper Senonian deposits.	
C. Upper Senonian	
3. Soft White Chalk with a few nodules of black chert	ca. 11.50
4. Kjölby Gaard marl (for a description, see the following chapter). Upward and downward the marl passes gradually into ordinary White Chalk	ca. 0.35
5. Soft White Chalk of the same type as Layer 3	ca. 5.00

In the present paper, only the fauna of the upper Senonian beds, which is very different from that of the coccolithic limestone of Danian age, is discussed. Among the macrofossils, the most important, from a stratigraphic point of view, are *Discoscaphites constrictus* (Sow.) and *Tylocidaris baltica* (Schl.), both of which occur sparsely throughout Layers 3 through 5. Of the very rich foraminiferal fauna, the following species may be mentioned: *Stensiöina pommerana* Brotzen, *Osangularia ("Parrella") lens* Brotzen, *Bolivinoides decorata* (Jones) subsp. *gigantea* Hiltermann and Koch, *Bolivinoides peterssoni* Brotzen, and *Neoflabellina reticulata* (Reuss). Layers 3 and 4 and the upper two meters or so of Layer 5 (the precise level of first occurrence is difficult to determine) are further characterized by the presence of *Pseudotextularia elegans* Rzehak and its varieties.

A particularly rich foraminiferal fauna was found in Layer 4, the Kjölby Gaard marl. Arenaceous forms are abundant, both as to species and individuals, and it was noted that, unlike the arenaceous foraminifera occurring in the ordinary White Chalk, these forms have incorporated quartz grains into their test walls. This is a natural consequence of the fact that the marl indicates an influx of terrigenous material into an otherwise very pure chalk deposit. Besides the species mentioned above, the Kjölby Gaard marl contains, among others, double-keeled *Globotruncana* species. Among them, only *G. contusa* (Cushman) occurs in any abundance, the others being represented by only one or two specimens each.

THE KJÖLBY GAARD MARL

The marl, described as Layer 4 of the section at Kjölby Gaard, has up to now received relatively little attention. Troelsen (1937) refers to it as the *Cumula*-horizon, and Wind (1954) calls it Blaakridt, i.e., "blue chalk," without, however, describing it in detail. Both names are unsatisfactory from a nomenclatorial point of view, and the name of Kjölby Gaard marl member is therefore proposed, with the following definition:

Type Locality: Abandoned shore-line cliff at Kjölby Gaard, 300 meters southwest of Hunstrup church, about 12 km. northeast of the town of Tisted (also spelled Thisted), in Tisted County, northwestern Denmark.

Description: Light gray marl with a high content of calcium carbonate. Small content of clay and minute quartz grains. At the type locality, the marl contains thin conformable laminae of soft white limestone. The laminae exhibit flow structure with random orientation. At all known occurrences the marl passes gradually, both upward and downward, into ordinary White Chalk. Thickness at the type locality about 35 cm., elsewhere 20 cm. to 50 cm.

Position in Section: At the type locality, about 11.5 meters below the top of the White Chalk; elsewhere (Erslev Andelsbrud) about 6 meters below the top.

Stratigraphic age: Late Cretaceous, late Senonian, late Maestrichtian.

Geographic distribution: In addition to its occurrence at the type locality, the marl has been observed at Nye Klöv, about 1.4 km. south of the type locality. It is also present at Erslev (or Eerslev) Andelsbrud on the island of Mors, Tisted County; at Vokslev (or Voxlev), about 3 km. southeast of the town of Nibe, Aalborg County; and in the chalk pits of the Dania cement factory, at Mariager Fjord, Randers County. All of these points are located in northwestern Denmark. Where the zone of *Pseudotextularia* has been examined in southeastern Denmark (Stevns Klint) and in southern Sweden (Höllviken), the Kjölby Gaard marl is absent. It is represented there either by White Chalk of the ordinary type or by an unobserved diastem.

Diagnostic fossils: In addition to the fossils that characterize the zone of *Pseudotextularia, Globotruncana contusa* (Cushman) is a distinctive element of the microfauna. *G. contusa* has been observed at all known occurrences of the Kjölby Gaard marl, except that at Vokslev. On the other hand, the species has never been reported from the ordinary White Chalk of Denmark and Sweden.

AGE OF THE WHITE CHALK AT KJÖLBY GAARD

In correlation charts of the Upper Cretaceous formations of northwestern Europe, the White Chalk at Stevns Klint in southeastern Denmark is usually mentioned as an example of the youngest Senonian deposits of the Danish-Swedish area. It is maintained by Brotzen (1945, pp. 61, 62) and by the present writer (Troelsen, 1937, fig. 2) that the uppermost White Chalk, which is separated from the overlying lower Danian limestones by a simple erosional disconformity, must be of very nearly the same age in Jutland, in northwestern Denmark (where Kjölby Gaard is located), at Stevns Klint, in southeastern Denmark, and at Höllviken in southern Sweden, since the upper 10 to 15 meters of the Chalk is characterized everywhere by the abundant occurrence of *Pseudotextularia elegans* Rzehak and its varieties.

With the exception of Wind (1954), who thinks that the White Chalk of Denmark should be referred to the Campanian, European workers have in recent years agreed that at least the White Chalk at Stevns Klint and its equivalents should be considered as of Maestrichtian age. This correlation is based upon the presence of such macrofossils as *Trigonosema pulchellum* (Nilsson) and *Discoscaphites constrictus* (Sow.). A historical review of the various stratigraphic interpretations has been given by Hiltermann (1953, table 1). The microfauna of the White Chalk shows but little resemblance to that of the limestone at the type locality at Maestricht in the Netherlands, presumably because of the marked difference in facies (for a recent description of the Maestricht limestone and its foraminiferal fauna, see Visser, 1951).

Opinions differ somewhat as to the length of the hiatus that separates the White Chalk of Denmark and Sweden from the overlying Danian limestones. Brotzen (1945, p. 62) argues that the hiatus must be a very short one, since the beds with *Pseudotextularia* seem to be present everywhere and with rather uniform thickness below the contact between the Senonian (Maestrichtian) and Danian beds of Denmark and Sweden. Most other authors maintain that the hiatus is a little longer in Denmark and Sweden than elsewhere in Europe, although there is but little agreement as to which other section is the most complete (Jeletzky, 1951, p. 74; Wicher, 1953, p. 9; Voigt, 1954, p. 643). All of these authors have come to the conclusion, however, that the top layers of the White Chalk in Denmark were deposited in the second half of late Maestrichtian time.

The presence, throughout the White Chalk at Kjölby Gaard, of *Tylocidaris baltica* (Schl.) shows that the sequence belongs to Zone IV$\beta+\gamma$ of the present writer's classification (Troelsen, 1937, fig. 1). The zone of *Tylocidaris baltica* corresponds at least to the upper, or greater part of Brotzen's Stevnsian (Brotzen, 1945, p. 59), which he considers to be the upper third of the Maestrichtian. In addition, the microfauna dates the sediments as upper Maestrichtian (cfr. Brotzen, 1945, and Wicher, 1953). Of particular interest is the presence of *Pseudotextularia elegans* Rzehak in the upper 13 to 14 meters of the White Chalk at Kjölby Gaard. In Denmark and Sweden the *Pseudotextularia* zone corresponds roughly to Jeletzky's zone of *Belemnella casimirovensis* (Jeletzky, 1951, pp. 70, 71, 74; Wicher, 1953, p. 18).

DISTRIBUTION OF GLOBOTRUNCANA CONTUSA

Before the significance of the occurrence of *Globotruncana contusa* in Denmark is discussed, a survey of its known geographic and stratigraphic distribution may be useful. The species was first reported by Cushman (1946, p. 150; here further references) from the Mendez shale of the San Luis Potosi area in Mexico, which both Keller (1937) and Wicher (1949) think is of Maestrichtian age. *Globotruncana contusa* was later reported from *Pseudotextularia*-bearing beds of Maestrichtian age in the western Caucasus (Keller, 1936, p. 654); from the Maestrichtian Tignale beds of Lago di Garda in northern Italy and from Maestrichtian beds of the central Apennines (Cita, 1948, pp. 150-151, and personal communication; Reichel, 1953, p. 345); from Middle Eocene beds of central Sicily (di Napoli Alliata, 1948, who considers it improbable that the tests are reworked from an older deposit); from beds of supposedly Maestrichtian age (Lantern marl and Pointe-à-Pierre Railway Cut marl) in Trinidad (Bolli, 1951, p. 196 and table 2); and from Upper Cretaceous (Campanian-Maestrichtian) beds on a flat-topped seamount west of the Hawaiian Islands (Hamilton, 1953, p. 208).

Should *G. contusa* eventually turn out to be conspecific with some of the more highly convex *Globotruncana* species (see, for example, de Lapparent, 1918, p. 8; White, 1928, p. 285; Vogler, 1941, p. 288; Colom, 1947, p. 33; Sellier de Civrieux, 1952, p. 282), the arguments presented in the present paper would still retain their force, since all of the strongly convex species are restricted in their known distribution to rather low latitudes.

SIGNIFICANCE OF G. CONTUSA IN THE KJÖLBY GAARD MARL

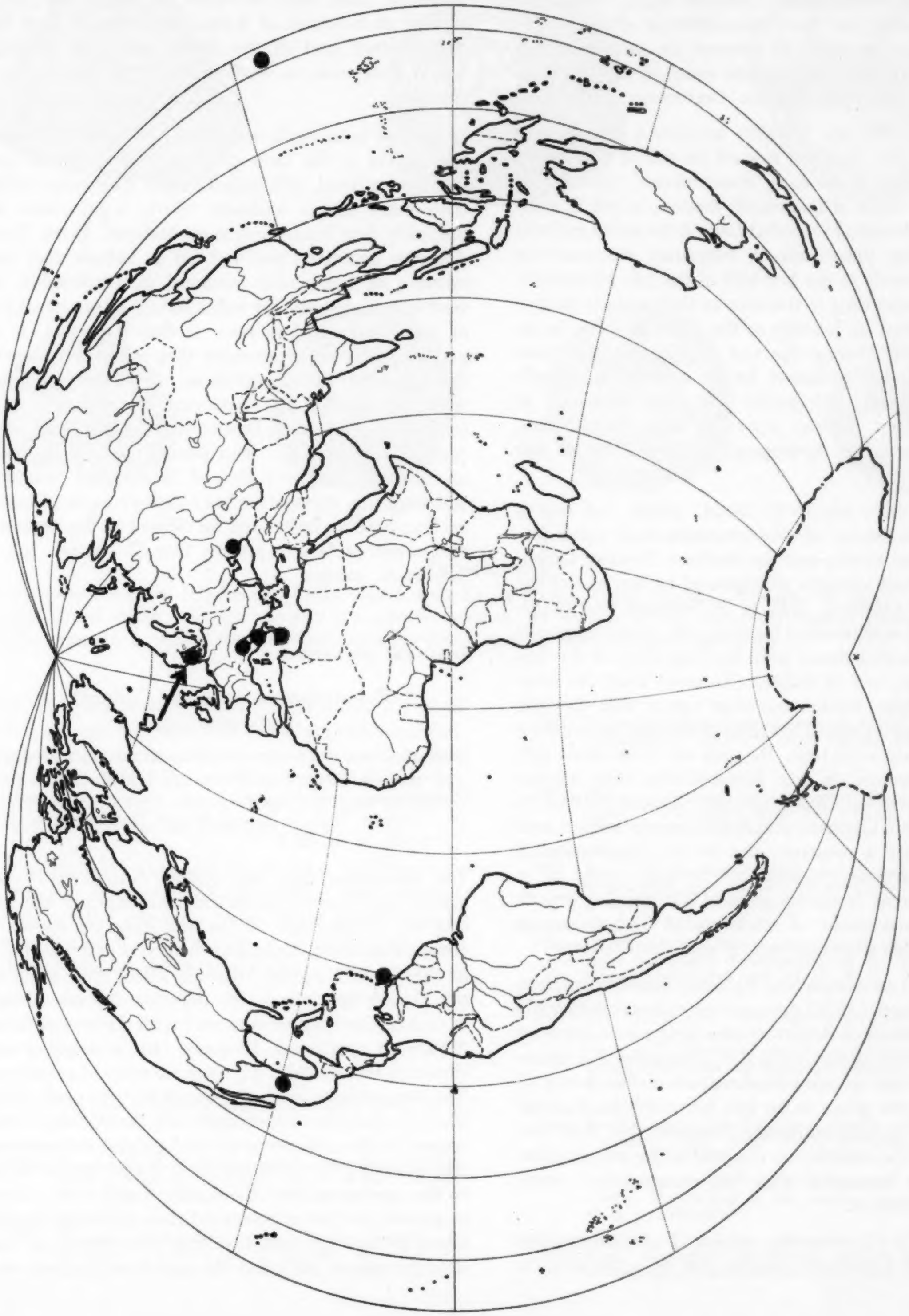
As mentioned in the description of the Kjölby Gaard marl, *Globotruncana contusa* has never been observed in the ordinary chalk facies of Denmark and Sweden, although it occurs rather abundantly in all known exposures, except one, of the Kjölby Gaard marl. In a benthonic species, such a mode of occurrence would hardly attract much attention, but because *Globotruncana* is generally considered to have been a planktonic form, it seems necessary to find an explanation for its apparent restriction to a certain lithofacies. It is further remarkable that *Globotruncana* should reappear in an area from which it had long been virtually absent.

The following possibilities have been considered:

(1) *The White Chalk is not a truly marine deposit, and the Kjölby Gaard marl member marks the establishment of a temporary connection with the open sea.* The absurdity of this hypothesis is demonstrated by the regular occurrence in the ordinary chalk facies of, among others, cephalopods, echinoderms and globigerinids.

(2) *The* Globotruncana *tests are not in place but have been reworked from another, slightly older deposit.* Although the tests show no sign of wear or corrosion, this possibility cannot be altogether excluded. It is, however, without decisive importance in the solution of our problem. As it is difficult to imagine how sediments could have been transported from the south shore of the Cretaceous Baltic Sea to northwestern Denmark, we are forced to assume that the terrigenous components of the Kjölby Gaard marl, including any reworked foraminifera, came from the Fennoscandian shield (the Scandinavian massif) a short distance northeast of the area occupied by the Kjölby Gaard marl. With a possible exception, *G. contusa* has been reported only from beds of the same age as the White Chalk (i.e., Maestrichtian and perhaps Campanian). If we assume that the reworked foraminifera came from deposits northeast of Denmark, we must still explain why *G. contusa* is absent from the ordinary chalk facies, of which numerous samples from many different levels have been examined.

(3) G. contusa *was not a planktonic but rather a benthonic species restricted in its habitat to a certain bottom-facies.* No direct evidence is known which will throw any light upon this hypothesis. It seems, however, that *Globotruncana* commonly occurs under circumstances that suggest a planktonic mode of life (cfr. Hamilton, 1953) .



TEXT-FIGURE 1

Geographic distribution of *Globotruncana contusa* (Cushman), as indicated by available literature and the present study. The arrow points to the group of occurrences in northwestern Denmark.

(4) *The deposition of the Kjölby Gaard marl and the invasion of northwestern Denmark by* G. contusa *in Maestrichtian time were two different effects of the same cause.* In order to attempt an answer to this question we must first review some of the literature on the hydrography of the Cretaceous Baltic Sea.

Jeletzky (1951, pp. 131-133) assumes a considerable cooling of the sea water toward the end of Cretaceous time, because, in the early Maestrichtian (corresponding to the zones of *Belemnella lanceolata* and *B. sumensis*), *Belemnitella* receded toward the south and was replaced by *Belemnella.* A temporary reappearance of *Belemnitella* in the first half of the late Maestrichtian (corresponding to the zone of *Belemnitella junior*) is interpreted by Jeletzky as the effect of a rise in sea temperature. During the rest of Maestrichtian time (represented in Denmark by the zone of *Belemnella casimirovensis*), *Belemnella* was again dominant in our area, but Jeletzky draws no very definite conclusions as to the hydrographic implications of this fact.

Wicher (1953, pp. 10-11, 20-23) points out that a progressive retreat of *Globotruncana* took place during the late Cretaceous. In southern Sweden, *Globotruncana* had virtually disappeared by the end of the Santonian (Brotzen, 1945, p. 38, footnote, and pl. 4), whereas in northwestern Germany the genus continued to occur in abundance until the beginning of the late Campanian, and in Poland (Pulawy) until the early Maestrichtian. Wicher therefore agrees with Jeletzky in assuming a general lowering of the sea temperature in late Cretaceous time. He goes on to conclude that the appearance, in late Maestrichtian time, of the southern species *Pseudotextularia elegans* Rzehak in northwestern Germany and the Denmark-Sweden area must signify a recurrent rise in the temperature of the northern sea, presumably brought about by a warm current from the south (Wicher also reports the rare occurrence of single-keeled Globotruncanas in the *Pseudotextularia* zone in northern Germany).

Although Lowenstam and Epstein's paleotemperature measurements (1954) demonstrate rather convincingly the correctness of the theory of a progressive lowering of sea temperatures during the Campanian and Maestrichtian, they give no confirmation of the theory of a warm-water phase in the late Maestrichtian. Lowenstam and Epstein emphasize, however, that they consider their information on this part of the stratigraphic column so incomplete that they cannot take a stand on this question.

As shown in the preceding section, *G. contusa* must be considered a southern species, and its appearance in great numbers in the Kjölby Gaard marl in the *Pseudotextularia* zone may therefore be interpreted as a sign of an incursion of warm water into at least the northwestern part of the Baltic area. Our findings would thus seem to confirm Jeletzky's and Wicher's theories.

It remains to be explained why *G. contusa* appears in the section at the same level as that in which clay and quartz sand, although in small quantities, make their entry into a sediment which is otherwise remarkably free from terrigenous material. Many Scandinavian geologists are inclined to believe that this scarcity of terrigenous material is attributable, at least in part, to very low relief and/or a certain aridity of the Fennoscandian area. If this is correct, it is, perhaps, possible to imagine that the warm current that brought *Pseudotextularia,* and later (perhaps when it reached its maximum temperature) also brought *G. contusa,* to Denmark caused an increase in precipitation over the land areas and therefore also an increase in the influx of terrigenous material. Although this explanation has a definite flavor of being *ad hoc,* nothing better can be offered at the moment, unless one prefers to assume that *G. contusa* was a benthonic species.

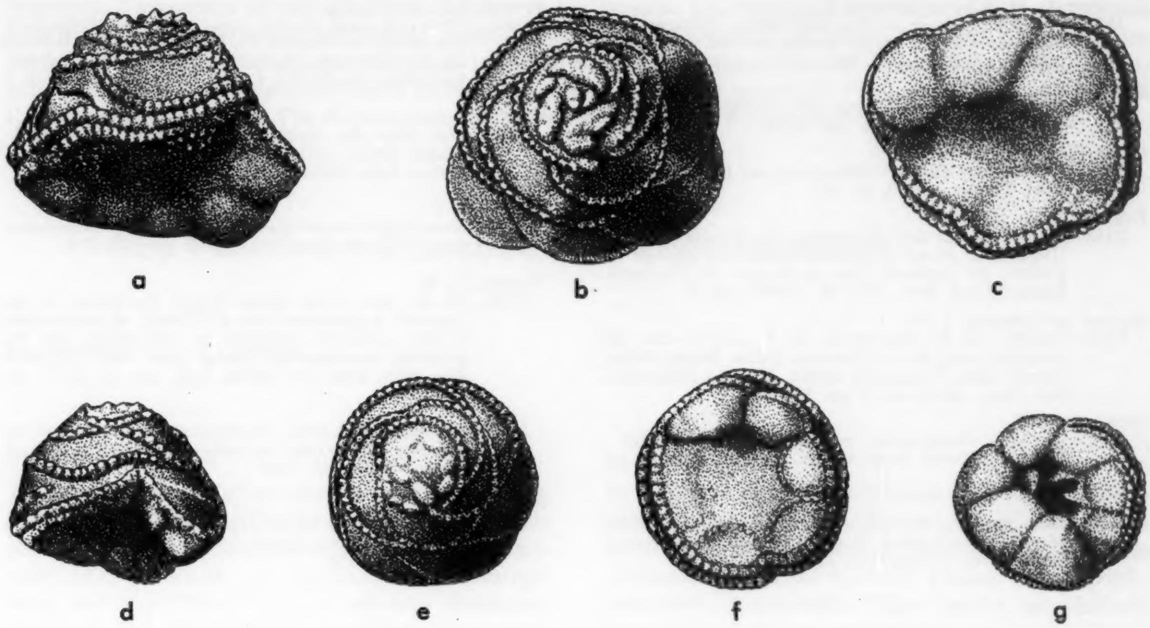
SYSTEMATIC DESCRIPTIONS

Globotruncana contusa (Cushman)
Text-figure 2a-g

Pulvinulina arca Cushman var. *contusa* Cushman, 1926, Cushman Lab. Foram. Res., Contr., vol. 2, pt. 1, p. 23.

Globotruncana arca (Cushman) var. *contusa* (Cushman).—Cushman, 1946, U. S. Geol. Survey, Prof. Papers, no. 206, p. 150, pl. 62, fig. 6.

The specimens from the Kjölby Gaard marl vary greatly with respect to the relative height of the test and the distinctness of the radiating plications. A comparison with Cushman's holotype and paratypes in the U. S. National Museum shows that some of the Danish specimens (for example, the one shown in text-fig. 2a-c) agree very well with the typical form. Numerous specimens, however (for example, those shown in text-fig. 2d-f, g), show no trace of plications. The two extremes grade imperceptibly into each other. There is complete agreement with the holotype with respect to the ornamentation and general shape of the chambers and the development of the peripheral keels. In the specimens from the Kjölby Gaard marl, which in general are better preserved than Cushman's specimens, it may be seen that the early chambers are strongly convex and that the umbilicus is large and



TEXT-FIGURE 2

Globotruncana contusa (Cushman). Kjölby Gaard marl; Kjölby Gaard, Tisted County, Denmark. All figures × 50. a-c, oblique lateral, dorsal, and ventral views of a plicate specimen. d-f, oblique lateral, dorsal, and ventral views of a nonplicate specimen. g, ventral view of a nonplicate specimen, showing apertural lips in umbilicus.

open. In specimens in which the umbilicus is free of matrix the apertures are seen to be large and rounded, opening into the umbilicus and covered by rather narrow but distinct lips (text-fig. 2g). Of seventy-five specimens chosen at random from the marl at Kjölby Gaard, seventy-two are dextrally coiled.

Distribution: For Denmark and Sweden, see the section on the definition of the Kjölby Gaard marl member. Except for the reference given above, those listed in the section on the distribution of *G. contusa* have not been checked by the present writer.

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Abstract: *Comparison of the calcareous skeleton of the Permian alga* Gymnocodium *with that of the Recent* Galaxaura *supports Pia's view that they are related. The Permian species are now divided between* Gymnocodium *Pia emend. and* Permocalculus *gen. nov., and placed in the family Gymnocodiaceae, new family, of equal status with the Recent Chaetangiaceae which includes* Galaxaura. *Two new species of* Permocalculus, P. digitus *and* P. plumosus, *are proposed. The Permian material figured and described is from northern Iraq, Middle East.*

The Permian calcareous alga Gymnocodium

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INTRODUCTION

The present study arose as a result of routine examination of material collected in the course of stratigraphic exploration by the geologists of Iraq Petroleum Company, Ltd. My thanks are expressed to the Management and the Chief Geologist of Iraq Petroleum Company, Ltd., for permission to publish this account; to Dr. F. R. S. Henson, the Company's Senior Research Geologist, who entrusted me with this work; to Miss Newton, Department of Botany, and to Mr. W. N. Edwards, Keeper of Geology, British Museum (Natural History), for facilities granted for examination of the national collections. I am also indebted to Mr. Edwards for his kind encouragement of my studies.

The algae discussed below are from a limestone formation in northern Iraq, geographically continuous with part of the Harbol formation of Turkey (Tasman, 1947) and about 800 meters thick. Resting unconformably on Lower Carboniferous rocks below, and passing above with apparent conformity into the Lower Trias, it is characterised throughout by the sporadic occurrence of the algae *Mizzia velebitana* Schubert and abundant *Gymnocodium bellerophontis* (Rothpletz), confirming the Upper Permian age established on faunal grounds by the Company's geologists. *Gymnocodium* was listed by Pia (1937) as occurring in the Upper Permian of the southern Alps, Yugoslavia (Croatia, Slovenia, western Serbia), and the Permian of Greece, Hungary and Iran; subsequently it has been recorded from Greece (Renz, 1946), Turkey (Taurus Mountains; Blumenthal, 1944), and the Salt Range, India (Rao, 1948; Rao and Varma, 1953). The present Iraq occurrences are further records in this old-world Tethyan Permian belt. It is also recorded from the southwestern United States (Johnson, 1951), Japan (Konishi, 1952), and the East Indies (Johnson, 1946). In addition to *Mizzia velebitana* and *Gymnocodium bellerophontis,* the Iraq Permian microflora includes some seven other species of *Gymnocodium,* and rare representatives of the typically Triassic genera *Diplopora* and *Macroporella.* These genera are similarly recorded as Permian rarities in New Mexico and Texas (Johnson, 1942, 1951), and *Macroporella* also in Sumatra (Pia, 1937).

SYSTEMATIC POSITION OF GYMNOCODIUM

The genus *Gymnocodium* was created by Pia, with type-species *Gyroporella bellerophontis* Rothpletz 1894 (Pia, 1920*a*).[1] Before this, he had interpreted the irregularly cylindrical and obliquely perforate calcareous units of this species as the skeletal elements of a normal dasyclad, and referred it to *Macroporella* (Pia, 1912). Recognising later that the short units were serial, bead-like structures somewhat like those of the Recent jointed *Halimeda* or the related fossil *Boueina,* he referred the species to the new genus *Gymnocodium* and transferred it to the Codiaceae (Pia, 1920*a*), a classification maintained in his textbook (Pia, 1927). Still later (1937), he created several new species and transferred the genus again, this time to the Chaetangiaceae, a change of some magnitude, since it involved transfer from the green to the red algae. For this reason, his comparison of the Permian *Gymnocodium* and the Recent *Galaxaura* (Chaetangiaceae) is discussed in some detail.

[1] *Gymnocodium bellerophontis* is listed several times by Pia (1920*b*) without definition; the date of this reference was later given as 1919 (Pia, 1937), but it appears to have been issued during 1920.

The red alga *Galaxaura* is represented in Recent warm-water seas by numerous species in which weakly calcified units or segments several millimeters in length are united to form a flexible jointed plant with thalles up to about 10 cm. in length. The sporangia of both sexual and asexual plants are internal; the differences occasioned in internal cell-structure between sexual and asexual individuals within one species has led to reference of such plants to different species (Howe, 1916). The calcification, although not truly external (a layer of plant cells forms an external skin or surface), is subdermal and forms a hollow tubular unit. In the calcareous green alga *Halimeda* the reproductive cells are wholly external to the segments and leave no trace in the calcareous structure; moreover, calcification extends throughout the segments to produce a semi-solid unit perforated by numerous canals.

These points were stressed by Pia in his comparison with the fossil *Gymnocodium*, in which the sporangia are similarly internal and the calcification mostly tubular. He discussed the arrangement and calcification of the plant thread-cells in *Galaxaura* and the sexual dimorphism met with in the genus; also the wide limits of Recent algal genera and the difficulty of selecting significant characters in classifying the fossils. Finally he placed *Gymnocodium* with *Galaxaura* in the Chaetangiaceae, and described or discussed seven species besides *Gymnocodium bellerophontis*.

Pia's comments on the calcification of *Galaxaura* afford little basis for detailed comparison with that of *Gymnocodium*, and the fossil is represented solely by this feature; moreover, the figures selected to illustrate an earlier account of *Galaxaura* (Pia, 1926) indicate the calcification merely by conventional shading. An examination of the collection of Recent *Galaxaura* in the British Museum (Natural History), Department of Botany, was therefore made by the present writer, with especial reference to the skeletal elements.

Under the microscope the non-calcareous surface skin is seen to be finely patterned with tiny circular depressions (pl. 2, fig. 2). The underlying calcareous layer shows a marked difference in structure between its two surfaces. The outer surface, immediately below the surface skin, shows circular pores about 0.010 mm. in diameter and 0.020 mm. to 0.040 mm. apart, opening into slight surface depressions so that the pore-mouths are separated only by gently convex surfaces, thus producing the patterning seen through the skin (pl. 2, fig. 2.). The inner calcareous surface shows a characteristic pattern of shallow depressions of rounded-irregular form separated by raised ridges; the circular pores already described open irregularly over this pattern, mostly over the depressions but occasionally on the ridges (pl. 2, fig. 1). The calcareous layer is about 0.030 mm. thick; within, the main interior of the segment is filled with thread-like non-calcareous plant fibres.

This structure is not identical with that of *Gymnocodium*, but it offers a clear basis of comparison with the structure seen in *G. bellerophontis*. Here the pores are oblique and not vertical to the thickness of the calcareous layer, and they open externally into funnel-shaped depressions, so that in section the ragged external outline is much more conspicuous than the inner, where the pore openings form a less prominent feature, somewhat the reverse of that seen in *Galaxaura*. Traces of irregular and patchy oblique-longitudinal streaks of calcification within the outer calcareous layer are sometimes met with in *G. bellerophontis*, and this feature appears to be well developed in *G. japonicum* (Konishi, 1952), where it was described as the pith. It seems to represent the plant threads already mentioned in *Galaxaura*. Secondary filling calcification is frequent in Permian species of *Gymnocodium*, but is usually distinguishable from original organic structures.

This type of structure occurs in one group of species of *Gymnocodium* which closely resemble *G. bellerophontis*, not only in calcification but in type and, to some extent, in size of segment. In a second group, of which *G. fragile* Pia may be taken as an example, the units or segments are larger and more varied in form, and the calcification is much more irregular in development, and finer in pore diameter. This type is less closely comparable with *Galaxaura* as described above, although it should be noted that types with finer calcification, more marked non-calcareous outer hairy skins, and other variant features are known in the Recent genus.

Pia's comparison of *Gymnocodium* with *Galaxaura*, discussed above, is thus supported by the fact that a comparable if not identical pattern of calcification occurs in both, and the importance of his recognition of affinity with the one comparable Recent genus is not diminished. It seems rash, however, to place them together in the Chaetangiaceae, in view of the rarity of closely comparable fossils in the long interval from Permian to Recent. *Gymnocodium nummuliticum* Pfender from the Cretaceous and Eocene is known to the writer only from the account of Pfender (1940), which suggests to him that it is not a true *Gymnocodium*, although similar in certain characteristics. *Corallinites galaxaura* Massalongo (1856) may be a Cretaceous *Galaxaura*.

Moreover, in view of the uncertainty that surrounds the fossils, which are nearly always found as disconnected segments, they are best classified on the basis of the structures actually available to the palaeontologist, rather than on their possible reconstructions. For this reason a new family, the Gymnocodiaceae, is proposed. It is to be of equal status with the Chaetangiaceae and to be grouped with it. The two groups of species of *Gymnocodium* are each assigned generic rank within this family. This classification is now set out in full, the various species briefly discussed, and their limitations as botanical species commented upon. Those figured are illustrated from the Iraq material.

SYSTEMATIC DESCRIPTIONS

Family **Gymnocodiaceae,** new family

Extinct Rhodophyceae[2] with thalles segmented or unsegmented, segments or units of varying size, form and degree of calcification, sporangia internal. Permian; central and southeastern Europe, western Asia, Salt Range, Japan, Indonesia, southwestern United States. Genera: *Gymnocodium* Pia, *Permocalculus* gen. nov., ?*Pilodea* Pia, ?*Hapalophloea* Pia.

Genus **Gymnocodium** Pia 1920, emend.

Gymnocodiaceae represented by hollow, calcareous segments, cylindrical, oval or cone-shaped, circular or oval in cross-section, rarely bifurcating; the walls perforated by pores which radiate oblique-distally and widen markedly outward; the segment-interior may be empty, or may show calcified traces of the plant-fibres that filled it in life, in the form of longitudinal-oblique streaks; sporangia ovoid, in terminal segments. Segments usually smaller than those of *Permocalculus,* and the perforations usually coarser. Type-species: *Gyroporella bellerophontis* Rothpletz.

Gymnocodium is interpreted as a plant very similar in life to *Galaxaura,* consisting of numerous thalles each composed of many segments, sometimes bifurcating, with the thalles growing in a bunch from the attachment.

Gymnocodium bellerophontis (Rothpletz)
Plate 1, figures 3-7

This is the familiar type-species, occurring in profusion, sometimes in rock-forming abundance, in the Upper Permian of central and southeastern Europe and western Asia. It was well described and figured by Ogilvie-Gordon (1927) and good figures were given by Pia (1937). Rothpletz's original text-figures are small, and the pore-dimensions given by him much less than those indicated by the figures (cf. Ogilvie-Gordon, 1927; Konishi, 1952), but his figures are recognisably those of *G. bellerophontis* as later interpreted.

The Iraq material shows segments up to 2.60 mm. long, diameter up to 1.25 mm., equatorial thickness of wall up to 0.15 mm., pore-diameter at outer surface 0.030 mm. to 0.050 mm. Bifurcating segments are uncommon; a terminal segment shows sporangia about 0.29 mm. in transverse diameter.

G. bellerophontis var. *pygmaea* Rao and Varma, from the Permian Middle Productus Limestone of the Punjab Salt Range, is described as similar to the parent species but smaller, and is apparently a local race.

G. nodosum Ogilvie-Gordon (Ogilvie-Gordon, 1927; Pia, 1937) is larger than *G. bellerophontis,* with segments of inflated or bulbous outline and deeply incised pores. It occurs in the topmost beds of the Upper Permian Bellerophonkalk in the South Tirol, below the passage to the Lower Trias, and appears to be a local terminal development. It was not observed in the Iraq material from a similar horizon.

G. japonicum Konishi appears to be close to *G. bellerophontis,* with which the author carefully compared it in detail. Apart from the differences in dimensions and proportions listed, it seems to show a greater and more frequent development of the calcified interior fibres ("pith" of Konishi) than is seen in *G. bellerophontis.*

Genus **Permocalculus,** new genus

Gymnocodiaceae represented by segments and units of variable form; spherical, ovoid or barrel-shaped segments, or elongate-irregular, finger-like or "waxing-and-waning" units. Calcification varying from very thin to massive or solid; pores small and cortical. Sporangia cortical or medullary. Segments or units usually larger, and the pores finer, than those of *Gymnocodium.* Type-species: *Gymnocodium fragile* Pia.

The segments of *Permocalculus* have sometimes been found in serial association and may be interpreted as successive segments of thalles as in *Galaxaura,* possibly several thalles to each plant as assumed for *Gymnocodium.* The larger, elongate units may have been basal portions of such a plant, or whole thalles growing singly or several to a plant, and are discussed below under the specific names.

[2] Classification of Fritsch (1945); class Rhodophyceae, subclass Florideae, order Nemalionales, family Chaetangiaceae.

Permocalculus fragilis (Pia)
Plate 1, figures 1, 2

G. fragile and *G. moniliforme,* from the Permian of Bosnia and western Serbia, respectively, were briefly described by Pia (1937) as almost spherical hollow segments, distinguishable by the size of the sporangia and the degree of calcification; only *G. fragile* was figured. The characters of the Iraq specimens are considered within the limits assignable to *P. fragilis;* Johnson (1951) similarly compared his American material with this species. *G. moniliforme* is in need of redescription if Pia's specimens are extant. *G. canea* Pia, for which no description or figures were given, should be treated as a *nomen nudum.*

The Iraq material assigned to *P. fragilis* varies considerably in size; dimensions (in millimeters) of five individuals are given below:

Specimen No.	1	2	3	4	5
Diameter	1.38	1.51	1.56	2.86	2.86
Approximate wall-thickness	0.182	0.130	0.156	0.182	0.260

The pores are fine, with an outer diameter of 0.010 mm. to 0.020 mm. The sporangia are oval, with a shorter diameter of about 0.20 mm., and are cortical in position. The species was very aptly named, for a profusion of debris occurs at many horizons.

P. piai (Rao and Varma), from the Salt Range, is spherical and thin-walled, but smaller than *P. fragilis,* and with medullary, not cortical, sporangia.

Permocalculus digitatus, new species
Plate 3, figure 6

This is a thin-walled species, the calcification and pores similar to those of *P. fragilis,* but finger-like in form, with somewhat flattened termination. The best-preserved specimen is about 2.08 mm. long, diameter 1.05 mm., wall-thickness 0.130 mm., pore-diameter about 0.020 mm., but incomplete examples are known up to 4.42 mm. in length and 2.08 mm. in width. Sporangia were not seen.

This fossil may be merely the basal portion of plants of *P. fragilis,* but is given a name as a recognisable form. Thin-walled elongate acuminate-ovoid segments in the Iraq material, up to 5 mm. in length, seem to form a connexion between *P. fragilis* and *P. digitatus* (pl. 2, fig. 4).

Holotype: The specimen figured in plate 3, figure 6, from the Upper Permian limestone of Harur, Mosul Liwa, northern Iraq; reg. no. W1.11342, Geological Dept., Iraq Petroleum Co., Ltd., London, England. *Paratype:* No. W1.11325, same horizon, locality and collection.

Permocalculus solidus (Pia)
Plate 2, figures 5, 6

This is a long digital species showing variable, often very heavy calcification, so that the older part of the thallus ("sterile thallus" of Pia) may be almost solid. Pia's material came from the Upper Permian of the Dolomites and western Serbia. The Iraq material referred to this species shows considerable variation in size, sections showing diameters up to 2.73 mm. A smaller example with diameter of 0.91 mm. shows a length of 2.86 mm. The pores, confined to the cortex, have a diameter of about 0.020 mm. A sporangium in the larger example is acuminate-oval in section, 0.416 mm. by 0.286 mm., is cortical in position, and communicates with the exterior by a short canal.

Specimens referable to *P. solidus* may in life have been the calcified basal portions of plants, or finger-like units. Material from the Permian of the Salt Range was identified as *G.* cf. *solidum* Pia by Rao and Varma (1953).

Permocalculus tenellus (Pia)
Plate 3, figure 1

This species was described from keg-shaped segments with thick finely-pored calcareous walls. Pia's figured specimens, occasionally branching, indicate a plant which in life was of *Galaxaura*-type.

The Iraq material shows segments about 2 mm. in length, diameter 1 mm., equatorial thickness of wall 0.25 mm., external pore-diameter 0.020 mm. to 0.026 mm., terminal segment-apertures about 0.180 mm. in diameter. The sporangia are circular in horizontal section and about 0.235 mm. in diameter.

Pia's material came from the Upper Permian of western Serbia. The American species *Gymnocodium texanum* Johnson was compared with *P. tenellus* by its author (Johnson, 1951).

Permocalculus compressus (Pia)

This species was very briefly described but not figured by Pia. Specimens showing the compressed cross-section described were noted in the Iraq material.

Permocalculus forcepinus (Johnson)
Plate 2, figure 3

P. forcepinus was described from the Upper Permian of Texas as a distinctive form in which the growing tip remains open. The Iraq material shows similar specimens of "waxing-and-waning" outline, with the bulge-diameters diminishing distally, thinly calcified, with wall 0.05 mm. in thickness, external pore-diameter

0.026 mm. to 0.030 mm.; length 8 mm., maximum diameter 2.5 mm. Sporangia were not seen.

Whilst *P. forcepinus* appears to be uncommon in the fossil floras, an uncalcified growing tip is frequently met with in living forms. In *Galaxaura*, "the thallus is calcified extensively and jointed due to the periodic loss of activity of the apical growing region and the subsequent production of one or two groups of meristematic tissue just beneath it" (Drew, 1951, p. 178); herbarium specimens of this genus sometimes show young terminal segments with uncalcified tips, the plant evidently having been collected during the period of rapid segment growth. It is thus possible that *P. forcepinus* indicates merely accidental preservation of this condition, but the unsegmented "waxing-and-waning" morphology suggests that this type had an uncalcified tip until growth ceased. Presumably in life the very thin marginal calcification permitted limited flexibility of the thallus, and this pattern can perhaps be regarded as more primitive than and possibly transitional to segmented types. Such different Recent calcareous algae as *Galaxaura*, *Corallina* and *Halimeda* are all segmented.

Permocalculus plumosus, new species
Plate 3, figures 2-5

This species in the Iraq material appears to be new. The thallus is of "waxing-and-waning" type, the bulge-diameters approximately equal, circular or oval in cross-section, hollow, with thin calcification showing radial-oblique pores, often fasciculate-branching, of *Gymnocodium*-type, but finer and not expanding markedly at their outer termination; in vertical section the inner wall-surface is more irregular than the outer, as in *Galaxaura*. A specimen of 2.86 mm. length shows a diameter of 0.70 mm., approximate wall-thickness 0.10 mm., external pore-diameter of 0.020 mm. to 0.025 mm. In vertical section diameters up to 1.45 mm. were seen. Sporangia were not observed.

Holotype: The specimen figured in plate 3, figure 5, from the Upper Permian limestone of Harur, Mosul Liwa, northern Iraq; reg. no. DM.2351, Geological Dept., Iraq Petroleum Co., Ltd., London, England. *Paratypes:* Numerous individuals in the same thin section.

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PLATE 1

All specimens figured are in thin sections from the Upper Permian limestone of northern Iraq, from localities in the north of Mosul Liwa, unless otherwise stated. Registered numbers quoted are those in the Geological Collections of Iraq Petroleum Company, Ltd., London, England.

Figure 1 *Permocalculus fragilis* (Pia)
Harur; W1.11342. × 28.

2 *Permocalculus fragilis* (Pia)
Ora; W1.8160. Left-hand specimen showing sporangium, × 28.

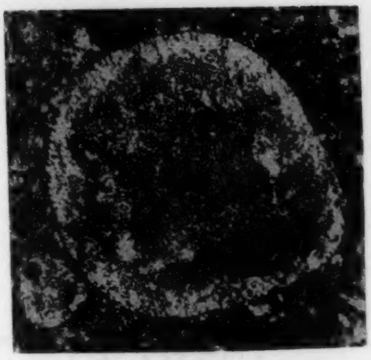
3 *Gymnocodium bellerophontis* (Rothpletz)
Ora; W1.8262. Oblique-vertical section of segment, × 28.

4 *Gymnocodium bellerophontis* (Rothpletz)
Harur; W1.11341. Transverse section of segment, × 28.

5 *Gymnocodium bellerophontis* (Rothpletz)
Ora; W1.8240. Oblique-vertical section through branching segment, × 28.

6 Rock showing numerous random sections of *Gymnocodium bellerophontis* (Rothpletz)
Ora; W1.8250. × 20.

7 *Gymnocodium bellerophontis* (Rothpletz)
Ora; W1.8250. Near-vertical section through terminal cone-shaped segment showing sporangia, × 28.



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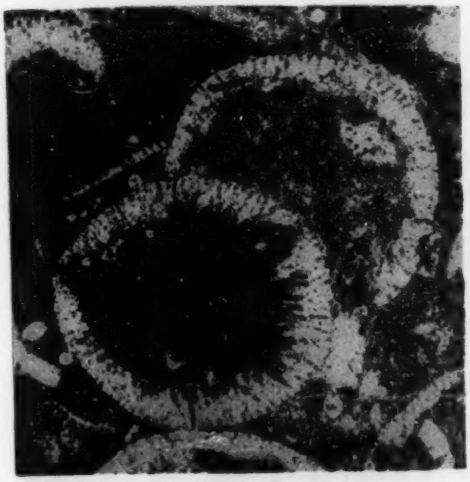

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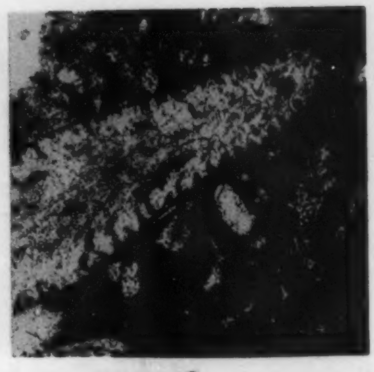

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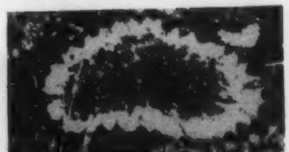

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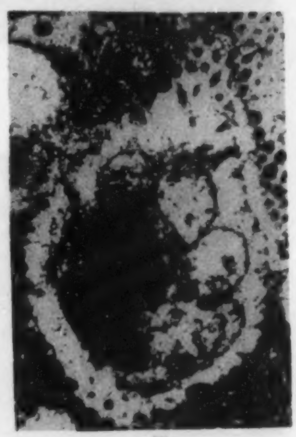

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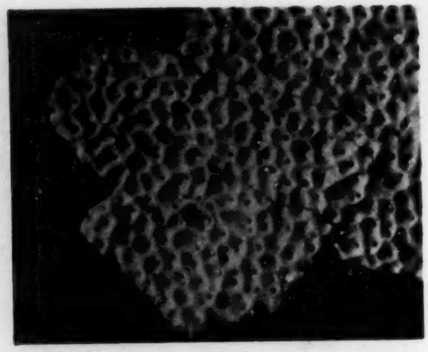

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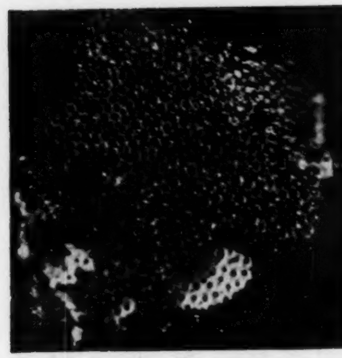

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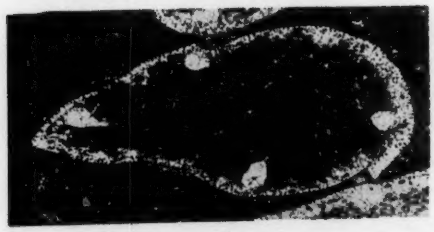

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PLATE 2

All specimens figured are in thin sections from the Upper Permian limestone of northern Iraq, from localities in the north of Mosul Liwa, unless otherwise stated. Registered numbers quoted are those in the Geological Collections of Iraq Petroleum Company, Ltd., London, England.

Figure 1 *Galaxaura* sp.
Recent; West Indies. Inner surface of subdermal calcareous layer, × ca. 50.

2 *Galaxaura* sp.
Recent; West Indies. Outer surface of portion of segment, showing outer, pitted, non-calcareous skin and outer surface of subdermal calcareous layer where the skin has been removed. × ca. 50.

3 *Permocalculus forcepinus* (Johnson)
Harur; W1.11327. Vertical section, × 10.

4 Elongate segment intermediate between *Permocalculus digitatus* and *Permocalculus fragilis*
Harur; W1.11325. Vertical section, × 10.

5 *Permocalculus solidus* (Pia)
Ora; W1.8187. Transverse section, × 28.

6 *Permocalculus solidus* (Pia)
Harur; DM.2351. Vertical section, × 28.

PLATE 3

All specimens figured are in thin sections from the Upper Permian limestone of northern Iraq, from localities in the north of Mosul Liwa, unless otherwise stated. Registered numbers quoted are those in the Geological Collections of Iraq Petroleum Company, Ltd., London, England.

Figure 1 *Permocalculus tenellus* (Pia)
Ora; W1.8112. Vertical and (top right) transverse sections of segments, × 28.

2 *Permocalculus plumosus* Elliott, n. sp.
Harur; DM.2351. Three transverse sections, × 28.

3 *Permocalculus plumosus* Elliott, n. sp.
Harur; DM.2351. Oblique-tangential section, × 28.

4 *Permocalculus plumosus* Elliott, n. sp.
Harur; DM.2351. Tangential section, × 28.

5 *Permocalculus plumosus* Elliott, n. sp.
Harur; DM.2351. Vertical section, × 28.

6 *Permocalculus digitatus* Elliott, n. sp.
Harur; W1.11342. Vertical section, × 28.

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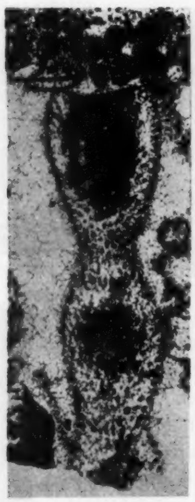

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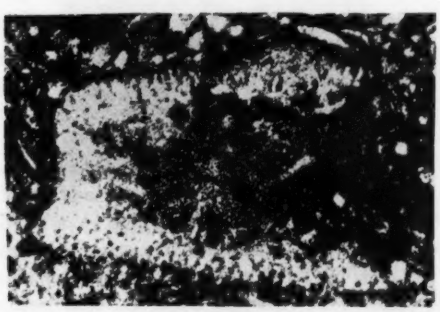

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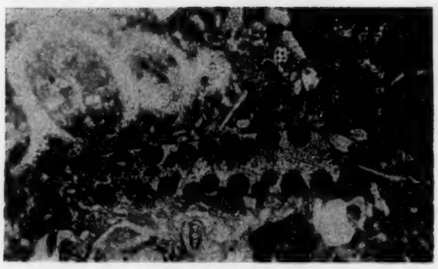

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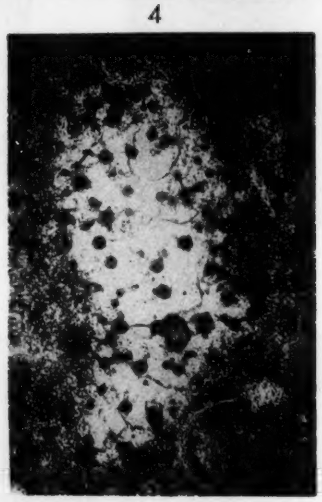

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EXPLANATION OF PLATE

Figures 1, 3, *Acicularia* sp.: 1, oblique section through a spicule, × 65; 3, longitudinal section through a spicule, × 40. Figures 2, 5-6, *Boueina pygmaea* Pia: 2, 5, oblique sections, × 40; 6, tangential section, × 65. Figure 4, *Indopolia feddeni* Rao and Vimal, n. sp., oblique section, × 35.

ABSTRACT: *Three species are described,* Acicularia *sp.,* Boueina pygmaea *Pia, and* Indopolia feddeni *Rao and Vimal, n. sp., from a limestone which is probably from the* Cardita beaumonti *horizon (Paleocene?).*

Fossil algae from Sind, Pakistan

S. R. N. RAO and K. P. VIMAL
University of Lucknow

INTRODUCTION

Though fossil algae are found in rocks of all ages, they are seldom used by geologists in correlation. To the few workers who are interested in this group of fossils, they have proved to be valuable indicators of age and facies. Many of the species have attained the status of index fossils on account of their limited vertical range and world-wide distribution. Calcareous algae are mostly microscopic and are often beautifully preserved in limestones and cherts. A single thin section may reveal a whole assemblage of genera and species. They are usually associated with foraminifera, and their study offers valuable aids to the micropaleontologist in problems of correlation and paleoecology.

The algae described in this paper are from a limestone collected during the period from 1874 to 1876 by F. Fedden, who was a member of the Geological Survey of India. Together with W. T. Blanford, he carried out pioneer researches on the stratigraphy of the Mesozoic and Tertiary formations of Sind. Through the courtesy of the Director of the Geological Survey of India, a small piece of this limestone was made available for our study. Six thin sections of this limestone have yielded the algae described here. The specimen bears G.S.I. No. 280/136 and is from the following locality: "Hills north of Ranikot, Banki Nala on the road to Lohi Lak (Pass)." Its age is given as Cretaceous or Eocene.

The following species have been identified:

(1) *Acicularia* sp. Calcareous spicules of this genus are common in the Cretaceous and the Lower Tertiary. The Cretaceous spicules are short and stumpy, while long, needle-shaped spicules characteristic of Paleocene and later beds (Rao, Rao, and Pia, 1938) have recently been observed in the Danian of southern India (Varma, 1954). The Sind species is very close to that described by Pia (Pia, Pfender and Termier, 1932) from the *Cardita beaumonti* beds of Morocco, which are considered to be Danian in age. Pia (1936), however, thinks that they are more probably Paleocene.

(2) *Boueina pygmaea* Pia. This was described by Pia (1936) from the Upper Cretaceous of Tripoli. The age of this bed is not known with certainty, and Pia thinks that the Tripoli microflora resembles that of the Danian of southern India.

(3) *Indopolia feddeni* Rao and Vimal. The genus *Indopolia* was founded by Pia (1936) on a single species, which he described as *I. satyavanti* from the Danian of the Niniyur beds of southern India.

A few foraminifera, *Rotalia sp.*, miliolids and *Verneuilina* sp., observed in thin section, resemble closely the microfauna which Pfender (Pia, Pfender and Termier, 1932) described from the *Cardita beaumonti* beds of Morocco.

Taking both the microfauna and flora into consideration, it appears that the limestone in question belongs to the *Cardita beaumonti* horizon of Sind. It is now well recognised that *C. beaumonti*, long regarded as an index fossil for the Danian, ranges from the Upper Cretaceous to the Paleocene (Rutsch, 1936). Cox, at a meeting of the Geological Society of London in 1939, while discussing the age of the *C. beaumonti* beds of Sind, stated that it would be necessary to refer them to the Paleocene because of their quite distinctive molluscan fauna. Eames (1952), in his classification of the Eocene of western Pakistan and western India, included the *Venericardia* shales (with *C. beaumonti*) in the Paleocene at the base of the Ranikot beds.

SYSTEMATIC DESCRIPTIONS

Family DASYCLADACEAE

Genus **Acicularia** d'Archiac, 1843

The history of the true nature of this genus is of considerable interest. The genus was founded in 1843 by d'Archiac for certain minute calcareous spicules found in the Calcaire Grossier (Eocene) of the Paris Basin.

He thought they were animals, and this opinion was accepted until 1877 when Munier-Chalmas removed *Acicularia* to the plant kingdom and with "rare divination" placed the genus among the Acetabulariae. As remarked by Solms-Laubach (1895), Munier-Chalmas' conjecture, which had little to support it in the fossil material, was later proved, in the most brilliant fashion, by the discovery of a living species of this genus.

These fossils, as already stated above, are valuable guides to the micropalaeontologist in differentiating the Paleocene and Lower Eocene from the Cretaceous.

Acicularia (Acicularia) sp.
Plate 1, figures 1, 3

Spicules are long and needle-shaped, with gamete cavities (sporangia) confined to the peripheral part.

Measurements

Length of spicules:	About 1.0 mm.
Greatest breadth of spicules:	About 0.3 mm.
Diameter of gametes:	0.06 – 0.08 mm.
Number of gamete cavities:	About 22.

Remarks: It is difficult to give specific names to these fossils when they are seen in thin sections. The following Indian occurrences of *Acicularia* are known: Danian of Trichinopoly (Rao and Pia, 1936; Varma, 1954); and Paleocene of Rajahmundry (Pia, Rao and Rao, 1937).

Genus **Indopolia** Pia, 1936

This genus was created for a single species, *I. satyavanti* Pia, which Pia (1936) described from the Niniyur beds (Danian) of Trichinopoly. The distinctive character of this genus is the presence of two sporangia on each primary branch. The primary branch is placed obliquely on the thallus. The genus very closely resembles *Neomeris,* which, however, bears one sporangium on each primary branch.

Indopolia feddeni Rao and Vimal, new species
Plate 1, figure 4

A few oblique sections passing through the calcareous skeleton have been observed. The primary branch is inclined to the axis of the thallus. Sporangia are probably spherical or pear-shaped, and two of them are seen at the end of a primary branch. There are twenty to twenty-four primary branches in each whorl. The diameter of the cortical layer is about 0.6 mm., diameter of the axial cavity about 0.55 mm., diameter of sporangia about 0.06 mm.

Remarks: This species is represented by a few fragments. The Sind species differs from *I. satyavanti* in having a larger axial cavity and smaller sporangia.

Family CODIACEAE

Genus Boueina Toula, 1884

Boueina pygmaea Pia
Plate 1, figures 2, 5, 6

Boueina pygmaea Pia, 1936, Jour. Pal., vol. 10, pp. 12-13, pl. 5, figs. 1-9.

This fossil is represented by many detached segments. The diameter is about 0.4 mm. The axial cavity is filled with an interwoven mass of tubes which have a width of 0.05 mm. to 0.65 mm.

The genus *Boueina* is very similar to the genus *Halimeda.* According to Pia, the only point of distinction is that the thallus of the former is unbranched, while in the latter it is branching. This distinction, however, cannot always be made in thin sections. As observed by Pia, *B. pygmaea* may possibly belong to the genus *Halimeda.*

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notes and comment

The value of an editorial board

R. M. STAINFORTH
Carter Oil Company
Billings, Montana

In the final issue of "The Micropaleontologist" (vol. 8, no. 4, pp. 26-27, 1954), Hofker expresses the view that young graduate students should be permitted to publish foraminiferal papers only in association with an experienced student. Apart from the obvious difficulty of deciding who should arbitrate in such cases, in my opinion it is impossible to generalize in such a sweeping manner. I can cite first papers of the highest order by youthful authors, and also shoddy papers by senior authors.

Hofker rightly cites Cushman as close to the ideal of a senior collaborator. The volume of letters presented to Dr. Cushman on the twenty-fifth anniversary of the founding of his laboratory gave eloquent proof of this. Nevertheless, viewed objectively, the papers of Cushman and his many collaborators almost all contain clear errors of specific and generic identification. I myself am sometimes embarrassed by such errors in earlier collaborative papers. For example, Tertiary species were referred to *Globigerina digitata, Globigerinoides conglobatus,* etc., although they were distinctly different from the types. These are errors so obvious that many young graduate students would manage to avoid them. Hofker is himself an experienced student, qualified by his own standards to act as senior collaborator in publishing younger students' theses; yet his individualistic approach to classification and his blatant disregard of the Rules of Nomenclature have aroused sharp controversy, and would render his aegis suspect in the eyes of some.

Many young students who want to pursue the study of foraminifera are forced by economic pressure to enter the foreign service of oil companies. Here they find themselves in the quandary of meeting new, significant, unpublished microfaunas but of having limited library facilities. It is to our general interest that they should publish the results of their studies, yet under the circumstances their synonymies and comparisons must be incomplete. Collaboration with a senior worker is difficult because most professors, museum curators and the like have their own full curricula of research work. In this connection, one wonders if the weaknesses in Cushman's collaborative papers were mainly due to his acceptance of more projects than could reasonably be handled in one laboratory.

It is clearly desirable that published papers should be as free as possible from objective errors, simple misidentifications, erection of new names for existing species, misuse of the codes of nomenclature and type-designation, and so on. It seems to me that control should rest with the editors of the journals concerned with foraminifera, and the blue pencil should be applied equally firmly to every manuscript, whether its author be tyro or professor emeritus. The plan announced by the editors of "Micropaleontology," to establish an editorial board composed of specialists in the various fields of micropaleontology, appeals greatly to me and should ensure high standards in the papers published by this journal. I believe that the control exercised by such a board is the most practical way of keeping objective errors to a minimum. Furthermore, an editorial board provides some control of subjective treatment. One cannot use the term "subjective errors," but there are certain generally accepted standards of style, conciseness, illustration, etiquette, and so on. Adherence to these standards would not be guaranteed merely by the signature of an experienced worker on each manuscript published.

Suggestions to authors

Manuscripts of all papers *other than news items,* submitted for publication in "Micropaleontology," should be sent to the Department of Micropaleontology, American Museum of Natural History, Central Park West at 79th Street, New York 24, New York. *News items,* however, should be sent to the correspondent reporting for the contributor's area. A list of correspondents, with their addresses, will be found on page 108.

Much unnecessary work and expense can be avoided if a standardized procedure is followed in the preparation of manuscripts. With this in mind, the following suggestions are offered to authors.

PAPER

Articles submitted for publication in "Micropaleontology" are to be typed on opaque, white, heavy-weight paper not less than 8 × 10 nor more than 8½ × 11 inches in size. The use of onion-skin or legal-size paper introduces difficulties for the editors and printers in reading and handling.

SPACING

All text, with no exceptions, is to be typed double-spaced. This rule includes the bibliography, the abstract, synonymies, quotations, tables, explanations of figures, etc. Standard-size (pica) type is preferable to small (elite) type.

ABSTRACT

All papers are to be accompanied by an abstract. It should be about 60 to 70 words in length, and is to be in English regardless of the language employed in the paper itself.

TITLE AND SUBJECT HEADINGS

The title of the paper should be not more than 75 characters in length, including spaces. Subject headings should be limited to about 45 characters. The title and headings of sections are to be typed in capital letters, without underlining.

ITALICS

In general, nothing is to be underlined for italics except the Latin names of genera and lower taxa when they occur in the running text or in the synonymy. No names are to be underlined in the systematic headings. Occasionally, a word or sentence in the text can be set in italics for special emphasis.

SYSTEMATIC HEADINGS

Inasmuch as this quarterly covers the entire field of micropaleontology, it is desirable to furnish a complete classification for the group or groups of organisms under discussion in the systematic section. Give the name of the phylum, class, order, family, genus and subgenus (if any), each preceded by the appropriate word. Other intermediate categories may also be given if desired. Be sure to verify the spelling, as the editors cannot do so for all groups of micro-organisms. Names of genera and subgenera are to be accompanied by author and date, for whose accuracy the contributor must be responsible. Omit the date in headings for species and lower taxa.

SYNONYMY

The form to be used for synonymy can be seen by examining papers printed in this quarterly. Note that the author of the systematic name is carried with each subsequent reference and is typed lower-case, whereas the author of the particular reference cited is typed in capital letters. In the reference in which a scientific name was first published as new, the author's name is typed in capital letters and is not repeated.

ELIMINATION OF FOOTNOTES

No footnotes are to be used. "Permission to publish" can be included under acknowledgments. Explanatory or tangential remarks should be incorporated in the text. If they are too irrelevant to be incorporated, they can probably be omitted without harm. The depository of types and other specimens can be cited in the introductory portion of the paper.

REFERENCES

Bibliographic references are to be identified in the text by giving the author and date of publication, with a page number if desired, and cited in full in the bibliography at the end of the paper. They should not be indicated as footnotes. Abbreviated references are to be used in synonymies.

STYLE AND LANGUAGE

Parenthetical remarks and long, involved sentences should be avoided. This is an international publication, and not everyone can follow a highly complicated style in a language other than his own. Relatively short paragraphs are also desirable.

Papers will be accepted for publication in any language that employs Latin characters. The editors and printers will do their utmost to reproduce all diacritical marks, but in some cases it may not be possible to do so. The abstract, as indicated previously, is to be in English regardless of the language employed in the text.

BIBLIOGRAPHY

The general form of the bibliography can be seen by examining papers already printed in this journal. The actual date of issue of the paper cited should be given as the date of publication below the author's name. Please note that many publications issued in parts do not always bear the same date as the year covered by the whole volume. Good examples of this point are the "Eclogae," of which Number 2 of each volume is always issued during the year following that of Number 1, and the Bulletins of the Geological Society of France, of which parts of each volume are issued during two or more years.

Note also that the titles of articles or books are to be underlined for italics, with nothing capitalized except proper nouns. The title ends with a period. For books, the place of publication follows the title, and is followed by a colon. After the colon, give the publisher, the volume number (if any), and the pagination. For serial publications, the word order and abbreviations to be used are shown in the "List of Publications" and "List of Abbreviations" issued as part of Volume 30 of the Catalogue of Foraminifera. The place of publication is to be omitted in citations of serial publications, except in cases of ambiguity or obscurity. Series, volume, and number or part are to be given, with their appropriate abbreviations. Complete pagination, plates and figures for the article cited should be given whenever possible.

ILLUSTRATIONS

All plates are to have a white background. The finished size of the plates will be 7 × 9 inches exclusive of margins. Original plates should therefore be mounted on a working field 7 × 9 inches in size, if no reduction is desired. If reduction is desired, the size of the field may be 9⅓ × 12, 10½ × 13½, 11⅔ × 15, or 14 × 18 inches. Printed numerals and letters of standard size and form, to be mounted on the originals, may be obtained from the editors. In requesting them, please indicate the dimensions of the original plates before reduction.

All specimens except sections are to be photographed with the illumination incident from the upper left side, as is conventional. Line drawings of specimens need not show highlights, but if it is desired to show illumination, it is to be indicated as coming from the upper left side.

Maps, tables, groups of drawings of specimens, etc., that are to be used as text-figures will be either 3 inches or 7 inches wide, and 8½ inches in maximum length, after reduction. All drawings must be in ink, on opaque white stock. Lettering on maps, graphs, etc., should be of such a size that they will be not less than 2 mm. high after reduction.

An explanation must be furnished for every figure. Magnifications should correspond to the finished size of the plate or text-figure, not to the original size as submitted.

L'ENVOI

In the interests of maintaining the editors' health and peace of mind, and especially of keeping down printing costs, it is earnestly hoped that contributors will make a sincere effort to conform to the foregoing suggestions. Papers which are otherwise acceptable for publication in "Micropaleontology," but which depart seriously from the style requested, will be regretfully returned to their authors for retyping.

news reports

EASTERN UNITED STATES

ALFRED R. LOEBLICH, JR.

During preparation of this report your correspondent wrote to every university suspected of having a geology department for news of activity in micropaleontology. Nearly all institutions have replied and are here thanked again for their cooperation. Unfortunately, however, no replies had been received from some of the active micropaleontologists before the deadline for this newsletter; hence, there are some unavoidable gaps. It is possible that others may have been unintentionally overlooked; therefore, your correspondent will be grateful if any oversights are called to his attention and hopes that readers will write to inform him of their activity in micropaleontology so that they may be included in future newsletters.

Smithsonian Institution (U. S. National Museum), Washington, D. C.

During the past year the U. S. National Museum has been visited by the following micropaleontologists: Dr. J. C. Troelsen, University Geological Institute, Copenhagen, Denmark; Dr. Eugenia Montanaro-Gallitelli, University of Modena, Modena, Italy; W. Akers, The California Company, New Orleans, Louisiana; Y. Nagappa, Assam Oil Company, Assam, India; Dr. Hans Bolli, Trinidad Leaseholds Ltd., Trinidad, B.W.I.; Mrs. Natalie Voshinin, Rutgers University, New Brunswick, New Jersey; Noel Brown, Cuban Gulf Oil Company, Havana, Cuba; Miss Dora Gutierrez, Lima, Peru; M. A. Ghorab, Shell Oil Company, Cairo, Egypt; Lawrence Weiss and James E. Faris, International Petroleum Company, Talara, Peru; M. Maldonado-Koerdell, Mexico City, Mexico; W. van den Bold and Harold Kaska, Trinidad, B.W.I.; M. V. Sastry, Calcutta, India; Lina Bolseiro, Bogotá, Colombia; Fernando Gutierrez, Quezon City, Philippines; Hans Pettersson, Göteborg, Sweden; M. A. Hanna, Houston, Texas; B. Biswas, Calcutta, India; A. Maurenbrecher, Bogotá, Colombia; Cesare Emiliani, Chicago, Illinois; and C. W. Thomas, Curtis Bay, Maryland.

Paleontologists from other countries, as well as the United States, are encouraged to visit the Museum and study the collections. Facilities provided include desk space, microscopes and lamps, etc. The arrangement of the collections facilitates easy reference. The large number of types and abundant comparative material and the excellent foraminiferal library makes the Museum one of the most important centers of foraminiferal study in the world today.

Dr. Alfred Loeblich is in charge of the foraminiferal collections and has an active program of field collection and exchanges to further increase their scope and usefulness. Dr. Helen Tappan Loeblich of the U. S. Geological Survey was recently appointed an Honorary Research Associate of the Smithsonian Institution.

The two Loeblichs are collaborating on the smaller foraminifera section of the "Treatise on invertebrate paleontology," which should be completed by the middle of 1955. The Loeblichs spent ten months in western Europe during the past year, studying and collecting in England, Scotland, France, Italy, Sicily, Spain, Belgium, the Netherlands, Germany, and Austria in connection with work on the "Treatise on invertebrate paleontology." The trip was made exceedingly pleasant and profitable by colleagues in these many countries, and to them the Loeblichs wish to express their sincere gratitude and their hope that this gracious hospitality encountered in Europe may be reciprocated. In addition to work on the Treatise, preliminary work has begun on the Recent foraminifera of Ifalik Atoll, western Carolines, a Pacific Science Board project of 1953; and, in collaboration with Dr. Hans Bolli, Trinidad, B.W.I., a revision of North American *Globotruncana* and related genera.

Two papers are in press, "Revision of some Recent foraminiferal genera" and "Revision of some glanduline Lagenidae (Foraminifera)," and several generic studies are in preparation in connection with the Treatise. Two were published by the Loeblichs during the past year; they will be found listed in the bibliography.

U. S. Geological Survey, Washington, D. C.

Foraminifera: Mrs. E. R. Applin, who is stationed at Jackson, Mississippi, has completed and sent to press "A biofacies of Woodbine age in the southeastern Gulf Coast." She now has in preparation a paper on a new foraminiferal fauna of Lower Cretaceous

(Coahuila) or Jurassic age from the subsurface of southern peninsular Florida.

Dr. Harlan Bergquist has recently returned to Washington, D. C., from Fairbanks, Alaska, and is completing stratigraphic studies and well correlations based on the foraminifera in northern Alaska. He is also studying the Cretaceous foraminifera of the Matanuska formation (Cretaceous) of Alaska.

Raymond Douglas is engaged in a monographic study of the genus *Orbitolina.* He has made collections from the Gulf Coast and southwestern areas of the United States for use in this project.

Lloyd Henbest is collaborating with Don Myers and Raymond Douglas in a monographic study of Pennsylvanian and Permian fusulinids from north-central Texas. Henbest is also studying fusulinids from the Sierra Diablo region of Texas in collaboration with field work by Dr. Philip King of the Survey.

Helen Tappan Loeblich was on leave from the U. S. Geological Survey from July, 1953, to July, 1954, and was a Guggenheim Fellow, travelling, studying types in museums and collecting in western Europe with Dr. Alfred Loeblich. At present, work is continuing on her study of foraminifera of northern Alaska in Naval Petroleum Reserve 4 for the Naval Oil Unit, Alaskan Branch. The second part of the Professional Paper, which concerns the Alaskan Jurassic species, is in press, and will appear early in 1955. The third section, on the Cretaceous species, is nearing completion. Several generic studies in collaboration with Dr. Alfred Loeblich have been published or are in press, and work is continuing on the smaller foraminifera for the "Treatise on invertebrate paleontology."

Mrs. Rita Post is making a comparison study of the foraminifera from the Funafuti and Bikini deep holes. She is also beginning the preliminary work on the Eniwetok deep hole.

Miss Ruth Todd has nearly completed a study of Recent foraminifera from the Gulf of Paria. Also nearing completion is the study of a Tertiary fauna from the Carter Creek region of northern Alaska. Miss Todd and Dr. Steven K. Fox, Jr., have in progress a joint study of the foraminifera from cores taken in western Mediterranean by the Swedish Deep-Sea Expedition Ship "Albatross." Miss Todd is collaborating with Paul Blackmon of the Geochemistry and Petrology Branch of the U. S. Geological Survey on an X-ray analysis study of foraminiferal tests. The following studies have been completed recently by Miss Todd and are now in press: Smaller foraminifera of Saipan, Mariana Islands; Recent foraminifera of the Marshall Islands and smaller foraminifera from the Bikini wells, Marshall Islands. Two papers (see bibliography) were published by Miss Todd during the past year.

Ostracoda: I. G. Sohn has completed the editing of H. N. Coryell's bibliography of Mesozoic Ostracoda, to be published by the Geological Society of America. In addition, Sohn is engaged in a revisionary study of the late Paleozoic ostracode genera and is working on several families for the "Treatise on invertebrate paleontology." During the past year Sohn collected ostracodes in Illinois, Indiana, Utah, Nevada, and California. Papers published are listed in the bibliography.

Dr. Jean M. Berdan has nearly completed a study of the ostracodes of the Manlius and Cobleskill limestones of New York. In addition, Dr. Berdan is preparing the descriptions of the families Kloedeniidae, Zygobolbidae, Drepanellidae and Beecherellidae for the "Treatise on invertebrate paleontology." Work is also in progress on the Ostracoda of the Helderberg group (Devonian) of New York and of the Middle Devonian of Nevada. Collections were made during the past year from the Ordovician and Devonian of New York and from the Silurian and Devonian of Nevada.

Conodonts: Dr. W. H. Hass has been actively engaged in conodont studies during the past year (see bibliography). Dr. Hass has in press two papers, "Age and correlation of the Chattanooga shale and the Maury formation," and "Preliminary report on the age and correlation of the Chattanooga shale and the Maury formation." The work on the conodont section for the "Treatise on invertebrate paleontology" has been completed and is now in the editing stage. A paper on the conodonts of the Chappel limestone of Texas is nearing completion, and work on the conodont faunal zones in the Upper Devonian of western New York and northwestern Pennsylvania is in progress. Conodont collections were made during the past year in the Devonian of New York and in the Mississippian of Illinois, Missouri, and Iowa.

Bryozoa: R. S. Boardman has published an interesting paper on "Morphologic variation and mode of growth of Devonian trepostomatous Bryozoa," and is engaged in a study of the trepostomatous Bryozoa of the Hamilton group (Devonian) of New York. Miss Helen Duncan has completed the "Annotated bibliography of bryozoan paleoecology" with a discussion, which will appear as a chapter in the "Treatise on marine ecology and paleoecology" (in press). Miss Duncan is continuing her researches on the Permian Bryozoa of the western United States and Alaska, and on the Bryozoa from the Devonian and Mississippian of the Rocky Mountains and Great Basin regions. Bryozoan collections were made from the Permian formations of Utah and Nevada and from the Devonian of Colorado.

U. S. Geological Survey, Coal Laboratory, Ohio State University, Columbus, Ohio

The laboratory is under the direction of Dr. James M. Schopf. Mrs. Marcia Winslow has nearly completed a monographic study of plant spores from the Upper Devonian shales of Ohio.

Ohio State University, Columbus, Ohio

Dr. Charles Summerson is studying an extensive collection of arenaceous foraminifera and scolecodonts from the various Devonian bone-bed localities of western Ohio. Edwin Defeu is studying a collection of nonmarine ostracodes from the Pennsylvanian of Ohio. Dr. Grace A. Stewart and Dr. W. C. Sweet are collaborating on a study of

conodonts from various bone-bed localities in the Columbus and Delaware limestones of Devonian age. Dr. Sweet has a paper on Ordovician conodonts from Colorado in press, and has begun a study of the Upper Ordovician conodont faunas from the Cincinnatian strata (Ordovician) of Ohio.

Rutgers University, New Brunswick, New Jersey

Mrs. Natalie Voshinin is studying the foraminifera of Eocene age from wells in New Jersey.

Virginia Polytechnic Institute, Blacksburg, Virginia

Dr. Wayne E. Moore has submitted to the Florida Geological Survey a manuscript on the geology of Jackson County, Florida, containing a study of the larger foraminifera of the area. A manuscript is in preparation on observations of live Miliolidae from Florida Bay, from a culture that has been under observation for some ten months. A manuscript on the ecology of foraminifera in Florida Bay is in preparation. Dr. Moore is being assisted in part of his studies by Bruce Hobbs, Carl Meyertons, John Hainer, Wendell Shanholtz, and Fletcher McCutcheon.

Duke University, Durham, North Carolina

Dr. E. Willard Berry reports two projects in preparation. The first involves the analysis of the spore content of coals of Karoo to Cretaceous age, from localities ranging from Natal to Sudan. The second study involves some larger foraminifera from British East Africa.

Florida Geological Survey, Tallahassee, Florida

Dr. Harbans S. Puri has completed a paper which is expected to be published early next year, on the "Structure, reclassification and evolution of the family Nummulitidae." Structure of all nummulitid genera is discussed in detail and a new classification is proposed on the basis of these structural features.

In addition, Dr. Puri is working on the Recent microfauna of the west coast of Florida. An article on the Ostracoda is now ready for publication, and the study of the foraminifera is in progress. Articles on the foraminifera of the Hawthorne and Avon Park formations are also in preparation. In a monograph, "Zonation of the Ocala group," to be published early next year, Dr. Puri will describe the microfauna of the Ocala group.

University of Alabama, University, Alabama

Mrs. Peggy Devonshire is currently working on the Cretaceous and Tertiary ostracodes of Alabama. James Z. Harris is planning to write a thesis on the foraminifera of the Providence sand member of the Ripley formation (Cretaceous) of Alabama.

University of Mississippi, University, Mississippi

Dr. Robert H. Shaver is currently working on the ostracode family Healdiidae for the "Treatise on invertebrate paleontology."

Mississippi State College, State College, Mississippi

Dr. P. H. Dunn is engaged in a study of Silurian foraminifera from Missouri, Tennessee, and Mississippi. Gene B. Martin is studying Upper Ordovician Bryozoa from northwestern Alabama.

Recent Publications

BOARDMAN, R. S.
1954 – *Morphologic variation and mode of growth of Devonian trepostomatous Bryozoa.* Science, vol. 120, p. 322.

HASS, W. H.
1953 – *Conodonts of the Barnett formation of Texas.* U. S. Geol. Survey, Prof. Papers, no. 243-F, pp. 69-93.
1954 – *Age of some black shales in cores from northeast Mississippi.* Mississippi Geol. Soc., 11th Field Trip, Guidebook, pp. 32-33.

LOEBLICH, A. R., AND TAPPAN, H.
1954 – *Emendation of the foraminiferal genera Ammodiscus Reuss, 1862, and Involutina Terquem, 1862.* Washington Acad. Sci., Jour., vol. 44, no. 10, pp. 306-310, text-figs. 1-2.
1954 – *The type species of Bulbophragmium Maync, 1952.* Micropaleontologist, vol. 8, no. 4, pp. 32-33.

PURI, H. S.
1953 – *The ostracode genus Trachyleberis and its ally Actinocythereis.* Amer. Midland Nat., vol. 49, pp. 171-187, 2 pls., text-figs. a-g.
1953 – *The ostracode genus Hemicythere and its allies.* Washington Acad. Sci., Jour., vol. 43, pp. 169-179, 2 pls., 2 charts.
1953 – *Taxonomic comment on: "Ostracoda from wells in North Carolina; Part 1—Cenozoic Ostracoda" by F. M. Swain.* Jour. Pal., vol. 27, pp. 750-752.
1953 – *Contribution to the study of Miocene of the Florida Panhandle.* Florida, Geol. Survey, Bull., no. 36, pt. 1 (stratigraphy), pp. 1-68, 7 text-figs., 3 tables; pt. 2 (foraminifera), pp. 69-214, 30 pls., 11 tables; pt. 3 (Ostracoda), pp. 215-345, 17 pls., 14 text-figs., 12 tables.
1954 – *Check list of Indian Tertiary larger foraminifera.* Jour. Pal., vol. 28, pp. 185-194.

SOHN, I. G.
1954 – *Permian ostracodes from the Glass Mountains, Texas.* U. S. Geol. Survey, Prof. Papers, no. 264-A.
1954 – *Paleocene ostracodes from outcrops in Maryland.* Science (May).

TODD, R.
1954 – *The smaller foraminifera in correlation and paleoecology.* Science, vol. 119, p. 448.

TODD, R., CLOUD, P. E., JR., LOW, D., AND SCHMIDT, R. G.
1954 – *Probable occurrence of Oligocene on Saipan.* Amer. Jour. Sci., vol. 252, pp. 673-682, pl. 1, text-figs. 1-2 (with an appendix in which two new species of foraminifera are described, one by Bronnimann and one by Todd).

ALFRED R. LOEBLICH, JR.
U. S. National Museum
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MID–CONTINENT, UNITED STATES

DOROTHY JUNG ECHOLS

Missouri School of Mines and Metallurgy, Rolla, Missouri

Dr. Don L. Frizzell reports the following news: Micropaleontology at the

Missouri School of Mines and Metallurgy continues as usual. Currently, there is only one student doing work in elementary micropaleontology, although in past years there have been as many as eight. A single graduate student, B. G. Deaver, is working for a Master of Science degree. His thesis, a study of the foraminiferal family Anomalinidae, is expected to be completed before June, 1955. N. E. Crockett received his Master's degree in June, 1954. His thesis topic was "Foraminifera of the type section of the Archusa marl of Mississippi (Eocene, Claiborne group, Wautubbee formation)."

Dr. Frizzell's most recent publication is his "Handbook of Cretaceous foraminifera of Texas" (see bibliography). He is currently working on comparative studies of Recent otoliths and on the description of a new genus of foraminifera. In collaboration with his wife, Dr. Harriet Exline, he is also preparing a monograph of fossil holothurian sclerites, which is nearly completed. They have in press the section on the paleoecology of the holothurians, to be published as part of the "Treatise on paleoecology," and are also preparing the section on the Holothuroidea for the "Treatise on invertebrate paleontology."

University of Kansas, Lawrence, Kansas

Dr. M. L. Thompson is now Professor of Geology and Chairman of the Department. He has recently published an extensive paper on American Wolfcampian fusulinids (see bibliography).

University of Oklahoma, Norman, Oklahoma

Dr. R. D. Harris reports the following news from the Micropaleontology Department: Dr. Hubert C. Skinner is now with The California Company in New Orleans. He completed his Master's thesis, "Arkadelphia Ostracoda from southwestern Arkansas," in 1953, and his Ph.D. thesis, "Arkadelphia foraminifera from southwestern Arkansas," in 1954. Irwin Gold, a graduate student, is expected to complete his Master's thesis, on "Marlbrook foraminifera from southwestern Arkansas," in June, 1955.

L. L. McNulty is now with the Continental Oil Company in Roswell, New Mexico. His Ph.D. requirements will be completed in February; his thesis topic is "Austin foraminifera from northern Texas." C. O. Matesich will complete the requirements for his Master's degree in June; his thesis is on "Saratoga foraminifera from southwestern Arkansas." R. D. Alexander is now with The California Company in New Orleans. He has recently published a paper on "Desmoinesian fusulinids of northeastern Oklahoma" (see bibliography). Dr. Harris and R. W. Sutherland have published a note on a new genus *(Darbyellina)* and species of foraminifera from the Midway of Arkansas.

University of Arkansas, Fayetteville, Arkansas

Dr. Payne has left the university to work for an oil company. At the present time, no work in the field of micropaleontology is being done there, and there are no immediate prospects for work in this field.

University of Tulsa, Tulsa, Oklahoma

Dr. Edward Heuer reports the following news: A two-semester course in micropaleontology is offered, and Dr. Heuer is usually engaged in some phase of micropaleontological investigation. Because of the limited enrollment in the graduate school, however, there are very few graduate students doing research in micropaleontology.

In June, 1954, Francis S. Wilson, who is now with the Gulf Oil Company in Jackson, Mississippi, presented a Master's thesis on "Foraminifera from the Pennsylvanian Wolf Mountain shale near Graford, Texas." Wilson's work was primarily taxonomic, and did not include the Fusulinidae. He worked with an abundance of material and made numerous thin sections in an effort to determine as accurately as possible the nature and degree of species variation. His results, based on an analysis of thirty-eight species, representing twenty-six genera and eight families, indicate that thin sections are essential for the proper taxonomic evaluation of other Pennsylvanian foraminifera, as well as of fusulinids, and that many Pennsylvanian species show a wider morphologic variation than has been appreciated heretofore. The raw sample material used by Wilson was supplied by the Field Research Laboratories of the Magnolia Petroleum Company. Wilson's work is part of a series of paleoecological studies that have been in progress here for the past four years, involving Pennsylvanian faunas from several Mid-Continent areas.

St. Louis University, St. Louis, Missouri

Dr. Kenneth Brill has returned from his stay in Hobart, Tasmania, where he taught paleontology at the University of Tasmania on a Fulbright Fellowship. He reports that, at present, work is being done on one Bachelor's thesis, concerning the relationships between conodonts and sedimentation in the Bushberg sandstone.

Washington University, St. Louis, Missouri

There is considerable activity in the micropaleontologic laboratory at Washington University. There are five new students in general micropaleontology, and two in microbiostratigraphy.

Hal Levin, with a Master's degree from the University of Missouri, is now a graduate assistant in the Geology Department at Washington University and is working toward his Ph.D. degree. His thesis will be stratigraphic and micropaleontologic in nature, but his topic has not been finally decided upon as yet. Warren Trimm, a new student from Marietta College, is working toward a Master's degree in stratigraphy and micropaleontology. His thesis will be concerned with the subsurface Pennsylvanian in St. Louis County. His samples were obtained by Professor A. B. Cleaves from the Army Records Center Building Project. Warren Baumgartner, having completed the requirements for his Master's degree in October, 1954, is now working for The Texas Company in Elk City, Oklahoma. His degree will be conferred in January, 1955. His thesis is a statistical analysis of a Pennsylvanian species of *Cavellina.*

Recent Publications

ALEXANDER, R. D.
1954 – *Desmoinesian fusulinids of northeastern Oklahoma.* Oklahoma, Geol. Survey, Circ., no. 31.

FRIZZELL, D. L.
1954 – *Handbook of Cretaceous foraminifera of Texas.* Texas, Univ., Bur. Econ. Geol., Rept. Invest., no. 22, 232 pp., 21 pls.

HARRIS, R. W., AND SUTHERLAND, R. W.
1954 – *A new foraminiferal genus and species from the Midway formation of southwest Arkansas.* Oklahoma Acad. Sci., Proc., vol. 33 (1952), pp. 207-208, tfs. 1-2.

THOMPSON, M. L.
1954 – *American Wolfcampian fusulinids.* Kansas, Univ., Pal. Contr., no. 14 (Protozoa, art. 5), 226 pp., 52 pls., 14 tfs.

DOROTHY JUNG ECHOLS
Washington University
St. Louis, Missouri

PERU

LAWRENCE WEISS

Dr. R. M. Stainforth has been transferred to the Carter Oil Company at Billings, Montana. However, the French affiliate of the Standard Oil Company (N. J.) has requested Stainforth's services and, prior to establishing permanent residence in Montana, he will spend about six months working on the biostratigraphy of the new discovery area in France.

Your correspondent has assumed the duties of chief paleontologist at the Talara laboratory. He is engaged in wildcat well studies of the Sechura Desert and, when time permits, research on foraminifera. A short paper on Peruvian planktonic foraminifera is being prepared and will soon be ready for publication. E. T. Ashworth has been working with routine wells and various stratigraphic problems of the La Brea-Pariñas Concession.

The news from Lima also concerns transfers and personnel shifts. Edward Marks is leaving the International Petroleum Company's Lima staff to continue his studies in the United States. F. Amato, Richmond Oil Company, was transferred to Bogotá, Colombia. Srta. Dora Gutierrez is at the University of California at Berkeley on a Point Four scholarship.

At Zorritos, the Empresa Petrolera Fiscal staff is active in both routine and research paleontology. Dr. P. Verastegui is studying the stratigraphy of the lower Eocene sediments at Los Organos. A. Euribe is describing and figuring the foraminifera of the Oligocene Heath formation. He hopes to publish a paper on this subject in the future. J. Cruzado is currently undergoing micropaleontological training at the International Petroleum Company's Talara laboratory.

There is not much news from Lobitos. A. J. Knights has recently returned from his vacation in England and R. Phillips has been mainly concerned with routine well work. In eastern Peru, Eric Blissenbach, micropaleontologist for the Compañia Peruana Petroleo el Oriente, a joint German and Peruvian operation, is doing preliminary work on the zonation of Tertiary red beds by means of spores, pollen, and heavy minerals.

LAWRENCE WEISS
International Petroleum Company Ltd.
Talara, Peru

COLOMBIA

VICTOR PETTERS

Instituto Geológico Nacional

H. Buergl, head of the paleontological section, has begun a study of Tertiary microfaunas from northern Colombia. During the past spring, he collected about 1000 samples, ranging in age from middle Eocene to middle Miocene. Many of them are highly fossiliferous. Their examination will require most of the year 1955, especially since Buergl must devote a large part of his time to the study of Cretaceous mollusks.

Miss J. Dumit Tobón resigned from her position as trainee in micropaleontology and was married. We extend our best wishes for her future.

T. van der Hammen and his assistants in the palynological section have been concentrating their investigations on the Eocene and Oligocene pollen of the Eastern Cordillera. Pollen of palms of the family Mauritiaceae, which first appear at the Cretaceous-Tertiary boundary (Paleocene), become extremely abundant in the Oligocene and Miocene. A detailed study of the continental Tertiary of the western Andean region is also in progress.

Empresa Colombiana de Petróleos

J. P. DuBois hopes to add a micropaleontological section to the offices which operate in the De Mares concession.

Shell Company

Mr. McGullan is substituting for A. Maurenbrecher during the latter's home leave. Maurenbrecher plans to learn pollen work in the Netherlands, and it is expected that Shell will add this successful method to their other activities in Colombia. The number of pollen laboratories in this country would then be increased to three, the other two being operated by the Instituto Geológico Nacional and International Petroleum.

Socony-Vacuum Oil Company

K. Glazewski has taken the record among Colombian micropaleontologists for this year's vacation activities. By now, he should be somewhere near the southern tip of Africa after hunting lions in Nairobi (or himself being hunted by the Mau Mau?).

Richmond Petroleum Company

This company is reinstalling a paleontology laboratory in Bogotá. We have no doubt that it will uphold the high standards of the days when Ben Uhl was Richmond's paleontologist, about seven years ago. F. Amato, of the Peruvian staff, is in Bogotá to organize the laboratory. After his return to Lima, another member of the Peruvian staff will take over at Bogotá.

International Petroleum (Colombia) Ltd.

C. G. Allen, formerly with the Standard Oil Company of California, has joined the paleontological staff of Intercol. Other members are I. L. Polson and your correspondent. R. Sarmiento and R. Obando are in charge of the palynological section. Our laboratory, which had operated at some distance from headquarters for the past seven years, has been brought back to the main office building, principally as a result of the efforts of J. Dorreen. This was the only paleontological activity in which he engaged during his short stay in Colombia, but it was surely a very beneficial one. Dorreen was transferred to Stanvac at Calcutta, India, early in 1954.

Your correspondent was surprised to discover an old European acquaintance west of Barranquilla, on the Caribbean coast of Colombia. *Anomalina balthica* (Gmelin), accompanied by abundant *Cassidulina laevigata* d'Orbigny, occurs there in the Salgar formation. In the late thirties, the writer used this assemblage for differentiating the Pleistocene from the Pliocene in the Po Valley, where it has been used for this purpose ever since. This, however, is the first fossil record of *Anomalina balthica* in the Western Hemisphere. Neither the accompanying fauna nor the stratigraphic position of the formation contradicts a Pleistocene age.

VICTOR PETTERS
International Petroleum (Colombia) Ltd.
Bogotá, Colombia

POLAND

FRANCISZEK BIEDA

Micropaleontological work in Poland during the past few years has been concerned mainly with foraminifera and pollen. Among the papers on foraminifera already published should be mentioned those of J. Małecki that appeared during 1954 in the Yearbook of the Polish Geological Society for 1952. In one of these papers, he describes a new genus, *Flabellaminopsis,* from ore-bearing clays of Dogger age near Częstochowa. He found considerable variability in this genus, and differentiates nine species. In another paper he describes two new Tortonian genera, one of which, *Pseudotriplasia,* was found in the salt-bearing clays of Wieliczka and comprises six species. The other genus, *Phyllopsammia,* was found in the Miocene of Gliwice Stare and Benczyn, and is represented by a single species.

In Bulletin no. 87 of the Geological Institute, Warsaw, there have appeared short reports on current work. The results of some of this work have already been published, but some of the work is still in progress. There is a report by W. Bielecka on a larger paper published by the same author in collaboration with W. Pożaryski. This joint work is the first monograph on foraminifera that has been published in Poland since World War II. The authors describe sixty-one species and varieties, sixteen of which are new. This microfauna, which includes some Ostracoda, was collected from thirteen stratigraphic zones, ranging in age from Astartian to Purbeckian.

Among other papers published in Bulletin no. 87, there is a preliminary report by J. Sztejn on his work on Neocomian foraminifera from outcrops in central Poland. W. Pożaryski gives a list of foraminifera from clay, sand, and quartz silt below the continental Miocene in borings in Izbica Kujawska. The list comprises seventy-three species, one-fourth of which (eighteen species) are restricted to the upper and middle Oligocene.

A paper by K. Pożaryska on some index foraminifera of the Upper Cretaceous (Cenomanian to Danian) has been published in the Acta Geologica Polonica. Zones are defined partly on the basis of index forms and partly on the basis of assemblages. The genus *Globotruncana* was not included in this study.

In Poland, investigations on pollen from Quaternary sediments are continuing with great intensity. Several papers on Tertiary pollen have also appeared recently. Papers on Quarternary pollen have been published mainly in Bulletins no. 66 to 69 of the Geological Institute, Warsaw, under the collective title "Quaternary research in Poland." Single papers have also been published elsewhere.

Pollen research is going on in three scientific centers, Warsaw, Krakow and Wrocław. The most important of these centers is Krakow, where Professor Władysław Szafer and his group have published a number of papers. Among those on Tertiary pollen, special mention must be made of two papers. The first was written by Professor Szafer himself, who turned his attention to plant pollen in the course of his investigation of a recently discovered Pliocene flora in the Polish Carpathians. The second paper presents the results of research by Professor Szafer's collaborators and students. In this work on the Pliocene flora of the Czorsztyn region, we find the results of a study of a geologic profile based on the pollen method, involving upper Pliocene and lower Pleistocene beds from the locality Mizerna, which lies between Nowy Targ and Czorsztyn.

Another paper on Tertiary pollen was published by J. Doktorowicz-Hrebnicka. Samples of lower Miocene

brown coal sediments from Żary in Lower Silesia were studied by the pollen method. The author found that pollen from these sediments shows the same sequence as the pollen from brown coals west of the Odra described by Thiergart between 1938 and 1947.

Papers on Pleistocene pollen are increasingly numerous. Some of them are devoted exclusively to the study of pollen; in others, pollen is treated along with larger fragments of plants and with stratigraphic and sedimentation problems of the Quaternary. In this connection, first place must be given to Professor Szafer's paper on "Pleistocene stratigraphy of Poland." The author has brought together all known facts about glacial and interglacial deposits in Poland, including the results of his own research and that of his students employing the pollen method.

Other papers on Quaternary pollen relate principally to the two interglacial stages. M. Brem, J. Dyakowska, M. Sobolewska, and A. Środoń ("Pleistocene floras from Tarzymiechy") have written papers on pollen from the Mindel-Riss interglacial stage. Pollen from the last interglacial stage, the Riss-Würm, has geen discussed by K. Bitner, J. Raniecka-Bobrowska, A. Środoń ("Interglacial peat from Śmielin"), and S. Tołpa. Pollen from the last glacial stage and the postglacial stage is the subject of a paper by A. Środoń, in which the author presents the results of his research, using the pollen method, on late Holocene sediments in Łopuszna and Osielec.

Recent Publications

Bielecka, W.
1954 – *Researches on the microfauna of the upper Malm in central Poland.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 87, pp. 21-36, pl. 1.

Bielecka, W., and Pożaryski, W.
1954 – *Micropaleontological stratigraphy of the upper Malm in central Poland.* Poland, Inst. Geol., Prace (Mem.), vol. 12, pp. 139-206, pls. 1-12, 4 tfs.

Bitner, K.
1954 – *The paleobotanic characteristics of the interglacial deposits at Horoszki near Mielnik in Podlasie.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 69, pp. 79-91, 2 tfs.

Brem, M.
1953 – *Interglacial flora from Ciechanki Krzesimowskie.* [Polish with English summary.] Acta Geol. Polonica, vol. 3, pp. 474-480.

Doktorowicz-Hrebnicka, J.
1954 – *Pollen analysis of brown coal from the region of Zary (Lower Silesia).* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 71, pp. 41-108, 2 pls., 109 photos.

Dyakowska, J.
1952 – *Pleistocene flora of Nowiny Żukowskie on the Lublin Upland.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 67, pp. 115-181, 1 photo, 7 tfs.

Małecki, J.
1954– *Flabellaminopsis, new genus of agglutinated foraminifera from the Dogger in the vicinity of Częstochowa.* [Polish with English summary.] Polsk. Tow. Geol., Rocznik (Soc. Géol. Pologne, Ann.), vol. 22 (1952), pp. 101-122, pls. 3-5, 3 tfs.

1954 – *New genera of agglutinated foraminifera from the Polish Miocene.* [Polish with English summary.] Ibid., vol. 22 (1952), pp. 497-513, pls. 12-13, 5 tfs.

Pożaryska, K.
1954 – *The Upper Cretaceous index foraminifera from central Poland.* [Polish with English summary.] Acta Geol. Polonica, vol. 4, pp. 62-72, pls. 1-2, 28 tfs.

Pożaryski, W.
1954 – *Marine sediments of younger Oligocene in Kujawy (middle Poland).* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 87, pp. 9-20, 1 map.

Raniecka-Bobrowska, J.
1954 – *Pollen analysis of Quaternary profiles at Wola and Żoliborz, Warsaw.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 69, pp. 107-140, 3 pls., 1 tf.

Sobolewska, M.
1952 – *Interglacial at Barkowice Mokre near Sulejów.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 66, pp. 245-284, 1 pl., 2 tfs.

Środoń, A.
1952 – *Last glacial and postglacial in the Carpathians.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 67, pp. 27-75, 4 tfs.

1954 – *Pleistocene floras from Tarzymiechy on the River Wieprz.* [Polish with English summary.] Ibid., no. 69, pp. 5-78, 5 pls., 6 tfs.

1954 – *Interglacial peat from Śmielin near Nakło, Pomerania.* [Polish with English summary.] Ibid., no. 69, pp. 153-158, 1 tf.

Szafer, W.
1954 – *Pleistocene stratigraphy of Poland from the floristical point of view.* [Polish with English summary.] Polsk. Tow. Geol., Rocznik (Soc. Géol. Pologne, Ann.), vol. 22 (1952), pp. 1-99, pls. 1-2, 20 tfs.

1954 – *Pliocene flora from the vicinity of Czorsztyn (west Carpathians) and its relationship to the Pleistocene.* [Polish with English summary.] Poland, Inst. Geol., Prace (Mem.), vol. 11, pp. 179-238, pls. 1-20, 10 tfs.

Sztejn, J.
1954 – *Research on the foraminifera of the Lower Cretaceous of Poland.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 87, pp. 37-45, 1 pl.

Tołpa, S.
1952 – *Interglacial flora at Kalisz.* [Polish with English summary.] Poland, Inst. Geol., Bull., no. 68, pp. 73-120, 4 photos, 5 tfs.

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School of Mining
Krakow, Poland

EGYPT

RUSHDI SAID

During the year 1953-54, micropaleontological activity in Egypt received a great impetus because of renewed activity in the search for oil. This was a result of the settlement of problems between the oil companies and the Government, and of the passage of suitable regulations in the new mining law.

The Egyptian American Oil Company was granted concessions covering the

entire Western Desert of Egypt north of latitude 28° N. Don B. Eicher is back in Egypt as chief geologist of this new organization. He is by no means a newcomer to this country, as he was here formerly for several years as a micropaleontologist with the Standard Oil Company of Egypt, and was a correspondent to "The Micropaleontologist" for Egypt. His company is planning a study of the micropaleontology of this vast and little-known part of Egypt.

The International Egyptian Oil Company has taken over the concession of Wadi Feiran, a 1949 discovery that was abandoned by the Standard Oil Company of Egypt after its dispute with the Government. The resumption of exploration work in the Sinai area by the International Egyptian Oil Company has brought back to the profession an old-timer, W. Iskandar. After abandoning this field of work during the lean years of oil exploration, he is now a micropaleontologist with the International Egyptian Oil Company. At present he is engaged in routine examination of samples from three wells that are being drilled in the area.

Mr. Ghorab, of the Anglo-Egyptian Oil Company staff, has left Cairo for the U.S.A. He has a Fulbright grant for study and for research on the foraminifera of Egypt, to be carried on at the University of California. Mr. Bishay has left Cairo for The Hague, to conduct research on the larger Tertiary foraminifera. Mr. Souaya is still continuing his laborious studies on the Miocene biostratigraphy of the Gulf of Suez region.

In the academic world, Dr. S. E. Ansary has published a paper on the new foraminifera that he recently described from the upper Eocene, and is submitting for publication a longer paper on the upper Eocene fauna. Dr. A. Osman has published a paper that includes the stratigraphic results of his Upper Cretaceous work, and is submitting two papers on faunal descriptions of the Upper Cretaceous foraminifera of Sinai and one on the Cretaceous faunas of the Abu Roash region. In the laboratories of Cairo University, the writer and four graduate students have completed several studies (see bibliography). A paper on the Upper Cretaceous of North Sinai (Said and Kenawy) is now almost completed and will be ready to go to press early in 1955. It contains descriptions of some 300 species, together with several stratigraphic conclusions. Said and Kamel, after completing a taxonomic study of Recent littoral faunas of the Mediterranean, are continuing work on the distribution of the faunas. Said and Basiouni are working on a rich fauna from the so-called Pliocene rocks of Egypt. Said and Barakat are progressing with their study of the Lower Cretaceous faunas of North Sinai. Said and Phillip are studying thin sections of Pleistocene indurated oolitic limestones of the Mediterranean coast.

The pioneering work of Dr. A. Kassas of Cairo University on the pollen analysis of cores from the northern part of the Delta is now at a standstill. Dr. Kassas has left us to spend two years in the Sudan, and he is now engaged in other phases of botanical studies.

Recent Publications

ANSARY, S. E.

1954 – *A new foraminiferal fauna from the upper Eocene of Egypt.* Cairo, Univ., Fac. Engineering, Bull., vol. 1.

1954 – *Statistical study of some foraminiferal species from the upper Eocene of the Fayum area.* Ibid.

OSMAN, A.

1954 – *Upper Cretaceous foraminifera of western Sinai.* Cairo, Univ., Fac. Engineering, Bull.

SAID, R.

1954 – *Foraminifera from Egyptian lakes.* Cairo, Univ., Fac. Sci., Bull.

1954 – *Foraminifera from the Pliocene rocks of Egypt.* Washington Acad. Sci., Jour.

RUSHDI SAID
Cairo University
Cairo, Egypt

MIDDLE EAST

MAX CHATTON

This is the first news report from your new correspondent for the Middle East. R. C. van Bellen, formerly Divisional Paleontologist at Aleppo, Syria, and now at Kirkuk, Iraq, had to give up his services as a correspondent because of the press of other duties. This does not mean that your new correspondent has seized this opportunity merely to have something to do. Far from it! He took the assignment because he felt that this area, where micropaleontological work is so important in the petroleum industry, should be included in the news coverage of this quarterly.

These news reports will cover the areas of activity of the Iraq Petroleum Company and Associated Companies. They will be subdivided under two general headings: Iraq, and the Persian Gulf area, which comprises Qatar, the Trucial Coast, and Oman.

Iraq

Two paleontologists, H. V. Dunnington and R. C. van Bellen, are stationed at Kirkuk. In addition to work on the control of wells that are currently being drilled, they are working on the preparation of a rock-unit nomenclature for northern Iraq. Dunnington is responsible for the Mesozoic, and van Bellen for the Tertiary. Van Bellen is also engaged in a re-examination of Tertiary sections and in detailed correlations between outcrops and wells.

Dunnington is also investigating *Globotruncana* species ratios, a new *Rectogümbelina* from the Maestrichtian, and the *Problematina—Archaediscus* and *Trocholina* faunas of the Triassic. In

addition, he is engaged in some facies and sedimentary problems. He recently published a paper entitled "Stylolite development post-dates rock induration" (Jour. Sed. Petrol., vol. 24, no. 1, March, 1954). Besides all of these activities, he is now very busy with the preparation of a paper on "Generation, migration, accumulation and dissipation of oil in northern Iraq."

Persian Gulf

Your correspondent is the only paleontologist now stationed at Dukhan, Qatar. Most of his time is spent in the paleontological control and correlation of wells drilled in Qatar and the Trucial Coast. New species of *Dictyoconus, Laffitteina, Dictyoconoides, Pseudochrysalidina, Kathina,* etc., were found in the highly fossiliferous middle Eocene section of the Murban well (Trucial Coast). A paper describing these new forms and giving detailed faunal ranges is in preparation. W. Sugden, Area Geologist at Dukhan, is also engaged at present in some paleontological research on *Pfenderina* Henson, in connection with the rock-unit nomenclature for Qatar.

The Permian fauna of Oman (fusulinids, algae, *Lasiodiscus, Globivalvulina,* etc.) will soon be described in a paper on Oman stratigraphy by Dr. R. G. S. Hudson of our Geological Research Centre in London. It is also interesting that most of the species of *Nummulites, Assilina, Dictyoconoides, Alveolina,* etc., reported by Davies, Pinfold, Nuttall, and others from the Eocene beds of the Punjab Salt Range are present in the Tertiary fauna of southern Oman. Faunal correlations and facies problems involved between India and southern Arabia will be the subject of a future paper.

This news report would not be complete without mentioning the excellent paper by A. H. Smout of our Geological Research Centre in London, on the "Lower Tertiary foraminifera of the Qatar Peninsula." This paper was presented by Dr. Smout as his Ph.D. thesis at the University of London, and was published by the British Museum (Natural History) in February, 1954. It is a publication of very high standards, and includes descriptions of seventeen new species and three new varieties. It is essential to the understanding of the Rotaliidae. Our warmest congratulations go to Dr. Smout.

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INDIA

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The Cretaceous and Tertiary rocks along the southern foothills of the Shillong Plateau are receiving increasing attention. The Eocene rocks in this region are predominantly of calcareous facies, and contain abundant foraminifera and algae. A detailed account of the stratigraphy and palaeontology of this region is under preparation.

Further drilling in the new test well at Nahorkatiya has helped in gathering additional information on the distribution of microforaminifera in the oil-bearing Barail rocks. It has, however, not yet been possible to establish any firm correlation within the Barails, since the foraminifera so far found in these rocks are mainly long-ranging arenaceous forms whose occurrences are also very irregular.

Y. Nagappa, Palaeontologist of the Assam Oil Company, is now in the United States on a U. N. fellowship. He is working at the American Museum of Natural History, New York.

Bose Institute, Calcutta

A. K. Ghosh is carrying on an intensive search for fossil microflora and other organic remains in the pre-Cambrian sediments of Peninsular India as part of a project sponsored by the Burmah Oil Company Ltd. Altogether, fourteen specimens from the Vindhyan series (Torridonian) and one specimen each from the Gangpur series (Huronian), the Kolhan series, the Cuddapah system (Algonkian), and the Kurnool series (Torridonian) have been analyzed. Abundant carbonized wood elements with various types of pittings — scalariform, bordered, and apparently simple—and psilate spores have been recovered from carbonaceous quartzites (Gangpur series) and shales (Tadpatri stage, Cuddapah system). From the Lower Vindhyan rocks of the Semri and Kurnool series, some unidentifiable organic bodies and algal remains have been recorded. Numerous spores of various types, as well as carbonized wood elements, have been recovered from the Rohtas stage (Lower Vindhyan) and the Kaimur series (Upper Vindhyan). Several winged spores, similar to those from the Cambrian of the Punjab Salt Range and Kashmir, have been found in abundance in certain samples from Lower Vindhyan rocks. Ghosh has utilised the microflora for correlating the different rocks that he has studied.

Geological Survey of India, Palaeontological Section (Calcutta)

Micropalaeontological work, as well as work in other branches of palaeontology, has received considerable impetus from M. R. Sahni, who took charge in March, 1953, as Paleontologist to the Department. Research on several fossil groups is now being carried out under his guidance. A paper entitled "Monograph of the orbitolines found in the Indian Continent (Chitral, Gilgit, Kashmir), Tibet and Burma with observations on the age of the associated volcanic series," by M. R. Sahni and V. V. Sastri, is to be published shortly in Palaeontologica Indica. A second paper by the same authors, "New microforaminifera from the *Orbitolina*-bearing Cretaceous rocks of Burma and Tibet," will be published in the Records of the Geological Survey of India. An abstract of the latter paper will appear in Current Science.

The inaugural number of the Journal of the Palaeontological Society of India is expected to come out during the middle of December, 1954. It will contain about twenty-four papers, ten of which are of micropalaeontological interest. These papers are listed in the bibliography. Another paper to appear in this number is "The biometric analysis of fossil populations" by J. B. S. Haldane. This should be of considerable interest to micropalaeontologists, as it deals with the general problem of variation from a statistical point of view.

Birbal Sahni Institute of Palaeobotany (Lucknow)

S. C. D. Sah and S. N. Dube, under the supervision of R. N. Lakhanpal, are continuing their work on the research project on palaeobotanical investigations on the measurement of geological time in India, sponsored by the Indian Council of Scientific and Industrial Research. The study of the microflora of Indian coals is being continued by Prem Singh and K. M. Lele, under the supervision of K. R. Surange. Investigations of the Permian coals have revealed the presence in them of numerous seed cuticles, megaspores, and microspores.

Vishnu Mittre and P. K. K. Nair are engaged in pollen research on the palynology research project sponsored by the Indian Council of Scientific and Industrial Research. They are working under the guidance of R. N. Lakhanpal. K. Surayanarayana, under the guidance of K. R. Surange, is engaged in the study of microfossils in the Upper Gondwana shales from various localities along the eastern coast of India.

Lucknow University

A. K. Chatterji and Krishna Mohan, research students working under S. R. N. Rao, have completed their theses on the foraminifera of Kathiawar and other parts of western India. Their theses are to be submitted shortly for the Ph.D. degree at this university.

Chatterji's work includes a detailed study of *Lepidocyclina* from Kathiawar. He has described *Lepidocyclina (Nephrolepidina) borneensis, L. (N.) morgani*, a new variety of *L. (N.) martini*, and two new species of the subgenus *Trybliolepidina*, which he considers a valid subgenus. In addition to these forms, he has also described *Taberina* (=*Orbiculina* auctorum) *malabarica, Operculina bartschi, O. granulosa, O. malabarica, Sorites marginalis, Archaias angulatus, Gypsina globulus*, and *Austrotrillina howchini*.

Mohan's work is chiefly concerned with the study of the Miogypsinidae of Kathiawar, Surat and Cutch. From Kathiawar he has described *Miogypsina irregularis, M. (Lepidosemicyclina) bifida, M. (L.) thecidaeformis, Miogypsinoides* sp. indet., and two new species of *Miogypsina*. In addition to these forms, he has also described, in collaboration with B. S. Tewari, *M. (L.) indonesiensis* and *M. irregularis* from Cutch. Tewari and Mohan consider *Lepidosemicyclina* a valid subgenus.

S. B. Bhatia and Krishna Mohan have completed a paper dealing with the smaller foraminifera of the Miocene beds of Kathiawar. The paper includes a systematic study of the foraminiferal fauna, which is described and illustrated. The stratigraphic and palaeoecologic significance of the foraminiferal assemblage as a whole is discussed. They have recorded over sixty species belonging to the following genera: *Ammodiscus, Glomospira, Textularia, Clavulina, Quinqueloculina, Spiroloculina, Triloculina, Pyrgo, Lagena, Globulina, Nonion, Elphidium, Nonionella, Heterostegina, Reussella, Trifarina, Bolivina, Geminaricta, Rotalia, Eponides, Discorbis, Valvulineria, Asterigerina, Globigerina, Anomalina*, and *Cibicides*. The ostracode fauna is also receiving their attention.

Your correspondent and S. B. Bhatia have examined for microfossils several samples of Lower Palaeozoic rocks from Burma. These samples were obtained through the courtesy of the Director of the Geological Survey of India. Studies of thin sections from a Lower Silurian limestone from a locality near Kwetnapa village, Mandalay Dist., Burma, have revealed the presence of some interesting foraminifera — *Textularia, Padangia*, and a trochoid arenaceous form *(Haplophragmoides?)*. It is important to note that *Textularia* has been known to range from Devonian to Recent (Cushman, 1948), whereas the genus *Padangia* Lange has previously been known only from the Middle Permian beds of Sumatra and the Salt Range. The calcareous alga *Sphaerocodium* was also observed in this Lower Silurian limestone.

B. S. Tewari has completed the zoning of the Tertiary rocks of the Vinjhan-Miani area, Cutch, on the basis of the larger foraminifera. Thin sections of Miocene rocks have revealed the presence of the genus *Victoriella* Chapman. This form is being investigated in detail.

Your correspondent and B. S. Tewari have completed a paper dealing with stellate discocyclines from western India. They have described two new species of *Actinocyclina* and have redescribed *Asterocyclina alticostata* (Nuttall). S. N. Singh is continuing his investigations of the Eocene foraminifera of Rajasthan.

B. S. Jangpani, a former research student at this university, has visited parts of the Kumaon region in the Himalayas, on the Tibetan border, and has collected several samples from various localities, ranging in age from Cambrian to Cretaceous. In the Cretaceous beds he has identified several species of *Globotruncana*, as well as some Radiolaria and tintinnids(?). A paper dealing with these forms is in preparation.

A. R. Rao and K. P. Vimal are continuing their studies of the microfossil content of the Tertiary lignites of India. Vimal, a research student working under A. R. Rao, has completed his thesis on the microflora of the Tertiary lignites of India. His work is to be submitted shortly for the Ph.D. degree at this university.

A. R. Rao recently read a paper, at the forty-first session of the Indian Science Congress, on some fungal remains from the Miocene (Warkalli, Travancore, South Arcot, Madras) and Eocene (Palana, Bikaner) deposits. He has identified the genera *Phragmothyrites* Edwards and *Micro-*

thyriacites Cookson, belonging to the family Microthyriaceae. Some of these forms are similar to those found in the Tertiary rocks of India (Deccan Traps), Great Britain, and Australia. The family Microthyriaceae thus had a worldwide distribution during the Eocene and Miocene periods, and its presence suggests the prevalence of a warm temperate climate in these regions.

B. S. Trivedi has been awarded the Ph.D. degree by this university for his thesis on the microfossils of the Punjab Saline series. He is at present working on the microflora of the Gondwana rocks.

Mysore University

L. R. Rao is continuing his work on the Cretaceous orbitoids of the Ariyalur beds. Several species of *Lepidorbitoides* have been provisionally identified. Smaller foraminifera, mainly belonging to the families Lagenidae, Textulariidae, Anomalinidae, Amphisteginidae, and Rotaliidae, are also quite common. Detailed work is in progress on the genera *Nummulites* and *Discocyclina* from the Eocene beds of the Pondicherry Cretaceous area. L. R. Rao and S. S. Gowda are making a systematic study of the algal flora of the entire Cretaceous section (Cenomanian to Danian) of the Trichinopoly area.

Nagpur University

Mrs. S. Chitaley is continuing her work on the fossil microflora of the Intertrappean cherts (Paleocene) exposed near Mohgaon-Kalan village, Chhindwara Dist., Madhya Pradesh.

Recent Publications

ACCORDI, B.
1954 – *Calcareous algae from the Upper Permian of the Dolomites (Italy) with stratigraphy of the Bellerophon zone.* Pal. Soc. India, Jour. (in press).

BHATIA, S. B.
1954 – *The study of variation in some smaller foraminifera.* Pal. Soc. India, Jour. (in press).

EVANS, P., AND NAGAPPA, Y.
1954 – *Economic use of palaeontology with special reference to the oil industry.* Pal. Soc. India, Jour. (in press).

GOWDA, S. S.
1954 – *Fossil Holothuroidea from the Trichinopoly Cretaceous (S. India).* Current Science, vol. 23, no. 5, pp. 152-153.

HOWELL, B. F.
1954 – *Evidence from fossils of the age of the Vindhyan system.* Pal. Soc. India, Jour. (in press).

KOHLI, G., AND SASTRI, V. V.
1954 – *On the age of the Chikkim series.* Pal. Soc. India, Jour. (in press).

NAGAPPA, Y.
1954 – *Foraminifera of the genera Fabiania and Eorupertia from the Sylhet limestone, Assam.* Pal. Soc. India, Jour. (in press).

PURI, H. S.
1954 – *Facies, faunas, and formations.* Pal. Soc. India, Jour. (in press).

RAO, L. R.
1953 – *The problem of Danian, a review.* Current Science, vol. 22, no. 12.

1954 – *Siderolites from the Cretaceous rocks near Ariyalur (S. India).* Ibid., vol. 23, no. 1, pp. 9-10.

RAO, L. R., AND GOWDA, S. S.
1953 – *Occurrence of Clypeina (Dasycladaceae) in the Niniyur group (Danian) of the South Indian Cretaceous.* Current Science, vol. 22, no. 11.

1954 – *Solenoporaceae from the Cretaceous rocks of S. India.* Ibid., vol. 23, no. 6, pp. 177-179.

RAO, S. R. N., AND MOHAN, K.
1954 – *Microfossils from the Dogra slates (pre-Cambrian) of Kashmir.* Current Science, vol. 23, no. 1, pp. 11-12.

RAO, S. R. N., AND SINGH, S.
1954 – *Two species of Lepidocyclina from the agate conglomerates (Burdigalian) of the Surat-Broach region, W. India.* Pal. Soc. India, Jour. (in press).

SAHNI, M. R., AND SHRIVASTAVA, R. N.
1954 – *New organic remains from the Vindhyan system and the probable systematic position of Fermoria Chapman.* Current Science, vol. 23, no. 2, pp. 39-41.

SHARMA, R. S.
1954 – *On the Nerinea beds of the Pondicherry Cretaceous of S. India.* Current Science, vol. 23, no. 4, pp. 119-120.

SITHOLEY, R. V., SAH, S. C. D., AND DUBE, S. N.
1954 – *Plant microfossils from a carbonaceous shale (Krols) near Nainital.* Jour. Sci. Indust. Res., vol. 13B, no. 6, pp. 450-451.

SITHOLEY, R. V., VARMA, C. P., AND SHRIVASTAVA, P. N.
1953 – *Occurrence of vascular plants in the Cambrian rocks of India.* Jour. Sci. Indust. Res., vol. 12B, no. 12, pp. 645-647.

TEWARI, B. S.
1954 – *The genus Halkyardia from Kutch, western India.* Pal. Soc. India, Jour. (in press).

TRIVEDI, B. S.
1953 – *Megaspores and other plant remains from Lower Gondwana of Singrauli coalfield, District Mirzapur, U. P.* Indian Bot. Soc., Jour., vol. 32, no. 1, pp. 70-85.

TROELSEN, J. C.
1954 – *Internal structure and systematic position of the foraminifer Cerobertina.* Pal. Soc. India, Jour. (in press).

VARMA, C. P.
1954 – *On the algal genera Neomeris and Acicularia from the Niniyur (Danian) beds of the Trichinopoly area (S. India).* Nat. Inst. Sci. India, Proc., vol. 20, no. 3, pp. 298-304.

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AUSTRALIA

IRENE CRESPIN

In August, 1954, Professor I. M. van der Vlerk of Leiden, Netherlands, visited Australia to attend the second meeting of the Pan—Indian Ocean Science Association in Perth, Western Australia. He spoke on "Correlation of the Tertiaries of Europe and the Far East." Whilst in this country he spent a short time in Canberra and Melbourne. A symposium on "Subdivisions and correlation of Cainozoic rocks," led by Professor van der Vlerk, was held at the University of Melbourne, and interested palaeontologists from all States were invited to attend. Because of the writer's long interest in the larger foraminifera of the Indo-Pacific region, she was especially happy to be able to discuss the subject with this authority.

N. de B. Hornibrook of the Geological Survey of New Zealand spent six weeks during September and October in Australia to study the foraminiferal faunas of the Cretaceous and Tertiary of this country. He visited Canberra for talks with the writer and Dr. Kicinski, and visited Adelaide for talks with Dr. Glaessner. A visit from Professor Alan Wood of the University College of Wales is expected during 1955.

Considerable palynological work is now being carried out in the Botany Department of Melbourne University. It is mainly concerned with the identification and description of fossil pollen grains and spores occurring in Australian Cainozoic ligneous deposits. The team of workers, consisting of Dr. I. C. Cookson, Miss S. L. Duigan, and Miss K. M. Pike, is financed by the Commonwealth Scientific and Industrial Organization and the State Electricity Commission of Victoria. The project started with the palaeobotanical examination of Tertiary brown coal deposits and has lately extended to palynological examinations of sediments in Australasia, ranging in age from Cretaceous to Recent.

Dr. Cookson will soon return from overseas after attending the Eighth International Botanical Congress in Paris. She has been working with Professor Deflandre at the Laboratoire de Micropaléontologie in Paris, on fossil dinoflagellates and members of the Hystrichosphaerideae. Miss Duigan will return to Australia shortly after an absence of over three years. She has been working at Cambridge. Miss Pike is completing a study of the pollen grains of living members of the family Myrtaceae and has been investigating the pollen content of Tertiary lignites from Victoria and South Australia.

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NEW ZEALAND

N. DE B. HORNIBROOK

Your correspondent recently had the good fortune to spend several weeks visiting micropaleontologists in Australia and seeing something of Australian microfaunas and stratigraphy at first hand. I found Adelaide, in particular, an active center of micropaleontology. During three weeks at the University, interesting and valuable discussions were held with Dr. Martin Glaessner, Miss Mary Wade, and V. R. Rao, on a number of subjects including the Australian Tertiary sequence, the Cretaceous—Tertiary boundary, and the classification of the *Discorbis* group. Also working on foraminifera at Adelaide with the Mines Department of South Australia was Dr. Nellie Ludbrook, a former molluscan specialist. At the Adelaide Museum I saw something of the work of Dr. W. Riedel, who is studying discoasters and Radiolaria.

In Melbourne I had the pleasure of exchanging views on ostracodes with Mrs. Betty Kellett Nadeau, who still takes an active interest in ostracodes despite the demands of a family. Though my stay in Melbourne was brief, I found a great deal of interest to discuss with Allan Carter, one of Dr. Glaessner's former students, who is now working on foraminifera with the Mines Department of Victoria. At the National Museum of Victoria I was able to inspect the Parr Collection, which is under the curatorship of Edmund Gill. I was particularly fortunate in meeting Professor van der Vlerk in Melbourne and attending the conference on the Australian Cainozoic that was held in honor of his visit to Australia.

Finally, I spent nearly two weeks at Canberra with Miss Irene Crespin and Dr. Felix Kicinski at the Bureau of Mineral Resources, where I worked through a small portion of the extensive collections and learned something more about Indo-Pacific faunas. The net result of the visit was a small advance in the cause of Trans-Tasman correlation, and, what is more important, a great improvement in the liaison between micropaleontologists on both sides of the Tasman Sea.

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Directory of correspondents

The following list of correspondents is presented for the benefit of those who wish to submit news items for publication in this quarterly. Contributors should send such news items to the correspondents reporting for their own areas. Manuscripts of papers submitted for publication should *not* be sent to correspondents. They should be directed to: Department of Micropaleontology, American Museum of Natural History, Central Park West at 79th Street, New York 24, N. Y.

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